SPECIAL CONSULAR REPORTS.

STREETS AND HIGHWAYS

IN

FOREIGN COUNTRIES.

REPORTS FROM THE CONSULS OF THE UNITED STATES ON STREETS AND HIGHWAYS IN THEIR SEVERAL DISTRICTS, IN ANSWER TO A CIRCULAR FROM THE DEPARTMENT OF STATE.

ISSUED FROM THE BUREAU OF STATISTICS, DEPARTMENT OF STATE.

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SPECIAL CONSULAR REPORTS

ON

STREETS AND HIGHWAYS IN FOREIGN COUNTRIES.

CONTINENT OF EUROPE.

AUSTRIA.

REPORT BY CONSUL-GENERAL GOLDSCHMIDT, OF VIENNA.

HIGHWAYS.

In speaking of the construction, maintenance, and management of public roads in Austria a distinction must be made between the so-called Imperial or state roads, which are subject to the legislation and administration of the state, and the public streets and roads, which are subject to provincial legislation.

1. STATE OR IMPERIAL ROADS.

The principal regulations concerning the state roads have been given from case to case by special laws or orders. Of these may be mentioned provisional regulations for the maintenance of country roads, (order by the department of the interior of October 13, 1849, No. 415, E. B.); building and maintenance of those parts of imperial roads leading through communities (order by the department of the interior of March 20, 1855, No. 53); the clearing away of snow from state roads (law of January 2, 1877, R. G. Bl., Nos. 33, 34). In addition to this, order by the department of the interior of May 5, 1877, and of July 7, 1876 (R. G. B., No. 100).

The total length of state or imperial roads throughout the kingdoms and provinces at present represented in Parliament amounted in the year 1828 to 11,436 kilometres and in the year 1873 to 15,003 kilometres; therefore the increase in length in this time amounts to 24 per cent. of the latter figure. One square kilometre of state territory is consequently intersected by 0.0508 kilometre of state roads.

A. Construction of the State Roads.

Only the state roads of Bohemia and the Tyrol are throughout or with but few exceptions constructed in the manner of regular highways (Chausséen), that is to say provided with a stone foundation.

In the other provinces, as Moravia, Lower Austria, Upper Austria, Salzburg, Silesia, Styria, Carinthia, Carniola, Galicia, Bukowina, nearly all the state roads are constructed after the manner of country roads, that is without any stone foundation and built exclusively of ballast (broken stone).

In Lower Austria, for instance, only two-tenths of the state roads are built upon a stone foundation.

These state roads in the above provinces have as a rule originated from the old parish roads and ways, which in some cases have only been corrected and widened.

a. Transverse section of the state roads.

For the constructing of new state roads it is prescribed that the maximum breadth (even in the vicinity of large towns) should be 9.5 metres. Only the largest state roads, leading from the city of Vienna, have the exceptional breadth of 11.4 metres.

The normal transverse sections of the newly built state roads, which are all provided with a stone foundation, are shown in figures 1, 2, 3, and 4 of the annexed drawing.

As will be seen from the following drawings the width of the roadway varies, according to the importance of the road, from 6.3 to 8 metres, and the width of the banquette, on both sides, or in narrow valleys or ravines only on the valley side, from 0 to 1.6 metres.

The foundation pavement is from 24 to 32 centimetres, and the second ballast (of broken stones or gravel) placed thereon from 16 to 24 centimetres high. The convexity of the road surface is 1 in 50 to 1 in 30. The road ditch has an average depth of from 30 to 63 centimetres and a bottom width of from 30 to 63 centimetres. In the normal transverse section of the state roads for Moravia the foundation bed appears provided with exceptionally high bordering stones, which have the object of holding together the ballast.

The section of the state roads for Bohemia is essentially the same as that for Lower Austria, with the only difference that it has a width of roadway of 7.5 metres, a stone foundation of 37 centimetres, and a second ballast or covering of broken stones or gravel of 15 centimetres. The

five state roads leading from Vienna are in its immediate vicinity paved with granite cubes on account of the great traffic thereon. The total length of this paving amounts to 22,000 metres.

Fig. 1.

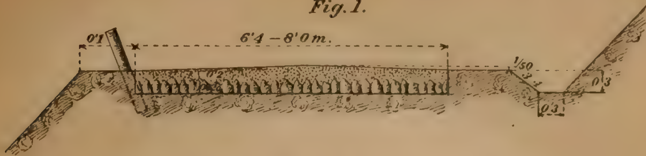


Fig. 2.

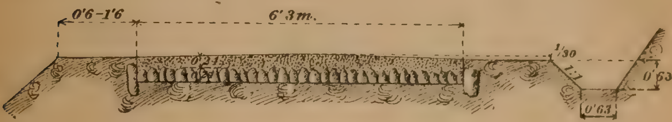


Fig. 3.

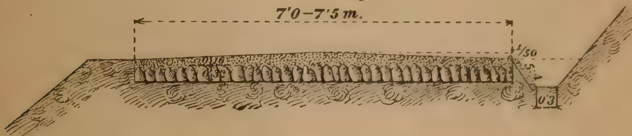
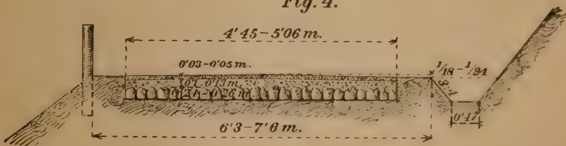


Fig. 4.



Closely connected with the width of the roads are the regulations of the road police, according to which, for instance in Lower Austria, Bohemia, Styria, and Carniola, the load of a wagon must not exceed 3 metres in breadth, while in Carinthia this maximum is fixed at 2.2 metres.

b. OTHER REGULATIONS.

Where there is a steep rise or fall of ground along the banks of the road a sufficient number of safety posts or bars must be provided. In the beginning of winter temporary roads must be marked out with poles or branches of at least 2 metres height upon such roads as are regularly rendered impassible by snowdrifts, and teams are obliged to use these temporary roads.

B. The Maintenance of the State Roads.

During the last century experiments have been made with the letting of the maintenance of the state roads to private parties, which experiments have, however, proved unsatisfactory. Then the Government took in hand the work of maintaining the state roads, and has adhered to this system up to the present day, with a short interruption in the years 1858–1861, during which time the keeping of the roads was again contracted for by way of experiment, which again gave but unsatisfactory results.

For the immediate carrying out of the work necessary for keeping in repair the state roads, road-keepers are employed by the Government, the number of which, according to the statement of 1872, was 3,625; consequently there was on an average one keeper for every 4.14 kilometres of state roads. Lately the number of road-keepers in Lower Austria and Salzburg has been reduced.

In larger districts road masters or inspectors are employed for conducting and superintending the work on the roads. The number of these inspectors in the year 1875 was 413, so that on an average there were 36.52 kilometres of road for every inspector to attend to.

a. METHOD OF MAINTAINING THE ROADS.

The maintenance of the Austrian state roads is carried on after the system of the so-called re-covering. After numerous experiments with other systems of keeping the roads, which have always failed, the above method has ever proved the best. According to this method the smaller defects of the road are continually repaired by the regular road-keepers, by removing the dust and mud from the ruts and hollows and filling them with gravel. It is then as a rule left to the passing wagons to pack these stones and roll them in. After certain longer periods of time, when the ballast of the roadbed has been thoroughly worn out, certain lengths of the road are again completely covered with ballast up to their normal height. This work is as much as possible carried out in wet weather, as a rule in the fall and spring of the year.

The rolling of the new layers of ballast, as formerly practiced, is now omitted. Experiments which have been made with rolling and with the so called patching system in the years 1856–1858, 1861–1864 and 1868 have neither financially nor technically given any satisfactory results. The reason for this may to a great extent be found in the circumstance that the most of the roads are not constructed in the manner of regular highways and were not provided with sufficiently thick layers of ballast.

b. CONSUMPTION OF BALLAST IN MAINTAINING THE ROADS, AND PROPORTION OF TRAFFIC.

Although the traffic upon the roads has not decreased since the building and development of the railways, but on the contrary has increased, the consumption of ballast (broken stones and gravel) upon the state roads has, since the year 1856, decreased continually. The average quantity of ballast per year and kilometre of state road amounted, in 1850–1856, to 93.3 cubic metres; in 1857–1864 to 70.7 cubic metres; and in 1865–1872 to 62.4 cubic metres.

From the proceeds of the tolls collected upon the state roads, an average traffic of 200 vehicles per day may be calculated. From this there results as the specific consumption of ballast, *i. e.*, per kilometre of road, per year, and with a daily traffic of 100 vehicles, a quantity of 31.2 cubic metres of ballast, taking the average of the 7 years' period of 1865 to 1872. This quantity must be considered as very small in comparison with the analogous requirements of other well-conducted countries.

In Lower Austria alone 180 cubic metres of ballast were used on an average per year and kilometre of state roads in the years 1850 to 1875; the maximum consumption was 285 cubic metres in the year 1853, and the minimum 130 cubic metres in the year 1863.

The average traffic on the roads of Lower Austria, however, is 800 vehicles per day. The average specific consumption of ballast therefore was 23.5 cubic metres.

In Bohemia, where excellent material for ballast is at disposition, the consumption of ballast, with an average traffic of 150 vehicles per day, amounted per kilometre and year, in the average of the years 1850–1875, only to 48 cubic metres, and in the year 1875 only to 40.4 cubic metres; consequently the specific consumption of ballast was 32 and 27 cubic metres, respectively.

c. THE CLEARING AWAY OF THE SNOW.

According to the regulations of the law, mentioned before (of Jan. 2, 1877), those communities (or estates), the territory of which is intersected by a state road, or which are not any further than 8 kilometres from such road, are obliged to cause the removal of the snow in so far as it is necessary for keeping up the traffic on such roads.

The Government, however, has the right to deviate from this rule and to cause the removal of the snow in any other manner.

The parties obliged to do this work receive a remuneration from the state road fund.

In those parts of roads, however, which are situated within a town, village, etc., as far as they form a passage through such town, etc., the respective town, etc., has to attend to without any remuneration.

C. The Passage Roads.

Of the costs of construction and maintenance of such parts of state roads as lead through towns, villages, etc., the state only pays the same amount as is required for the construction and maintenance of the continuation of the same roads outside of such towns, villages, etc. Therefore the removal of the mud scraped from such parts of roads and taken from the ditches thereof has to be attended to by the state road keepers.

When such parts of state roads forming a passage through towns, villages, etc., are paved throughout, the respective communities have to attend to the keeping of such roads. For this they receive a remuneration from the state road fund, but only in such proportion as if the road were a common highway (not paved).

D. Important Regulations of the Road Police.

All wagons built for a load of more than 2¼ tons must have wheels with rims of at least 11 centimetres width (Styria and Carinthia), and if they are built for more than 4½ tons (in Styria), or more than 3½ tons (in Carinthia) the rims of the wheels must be at least 16 centimetres wide.

In Lower Austria a width of wheel rim of 11.5 centimetres is prescribed for loaded wagons drawn by two or three horses, and in Bohemia the same for wagons drawn by two horses.

In going down hill the wheels must only be locked by means of brakes or drags (skid shoes), the latter of a minimum width of 18.4. The employment of chains for locking the wheels is not permitted.

If the road leads through woods, a clearance of at least 4 metres on either side of the ditch must be made.

The driving across the ditches, where there is no bridge or special crossing provided, or the driving on the blanquettes (borders) is forbidden, as well as the grazing of cattle on the latter.

E. Cost of Construction and Maintenance of State Roads.

During the period from 1828 to 1877 an average amount of 891,409 florins per year has been expended for the building and the more important reconstruction of state roads. The maximum costs, in the year 1874, amounted to 2,091,260 florins, and the minimum, in the year 1865, to 418,157 florins (since 1860). The maintenance of the gravel or broken-stone road surface, including the costs and transport of the stones, and the wages for workmen, etc., cost per kilometre of state road:

	Fl. kr.
In the year 1850	180.46
In the year 1869	167.88
In the year 1871	183.54
In the year 1873	207.02

The average cost for the period of 24 years from 1850 to 1873 may be calculated at 187 florins per year and kilometre of state road.

The amount of the total costs of maintenance, that is, for the road surface and for the other constructions appertaining to the roads, amounted from 1847 to 1873 to an average of 284 florins per year and kilometre.

In Lower Austria alone the expenses for the maintenance of state roads were 484 florins per kilometre in the year 1866, and in the years 1870–'73, on an average, 608 florins per year.

The average wages of the road-keepers and their assistants in the years 1868–1873 amounted to 43 florins 86 kreutzers per year and kilometre of road.

The average price of the ballast in the year 1873 was 2 florins 28 kreutzers per cubic metre.

In Bohemia the expenses for the maintenance of the road on the part of the state were as follows:

	Florins.
1877	1,239,197
1879	1,185,396
1881	1,074,920

Of these sums the expenses for the ballast alone were:

	Florins.
1877	639,706, or 52 per cent. of the total costs.
1879	586,464, or 50 per cent. of the total costs.
1881	526,521, or 49 per cent. of the total costs.

F. State Roads—Toll Receipts

In Austria the receipts of toll, collected upon the state roads in the average of the years 1860–1873, amounted to 2,618,549 florins net per year, with the maximum of 2,678,827 florins in 1861 and the minimum of 2,461,240 florins in 1873.

The net toll-receipts per kilometre of state road in the year 1873 was 172 florins 50 kreutzers.

In Lower Austria the annual net receipts for tolls increased from 554,612 florins in the year 1847 to 654,814 florins in 1873, in which latter year the annual receipts per kilometre of state road amounted to 914 florins.

In Bohemia these receipts increased in the above period from 478,217 florins to 553,002 florins in 1873.

The toll collected upon the state roads, the same as that for entering the city limits of Vienna, is:

	Kreutzers.
For a 2-horse vehicle	8
For a 1-horse vehicle	4
For one horse, not hitched	2
Per head of cattle	1

2. COMMON PUBLIC (NOT STATE) ROADS.

All other public streets and roads, which are not state roads, are subject to the independent administration of the single respective provinces, and with regard to them the respective provincial laws are in force. The most important of these laws are the following:

Province law for Lower Austria concerning the construction and maintenance of roads, not belonging to the state. (November 3, 1868. L. G. Bl. No. 17.)

Province law for Lower Austria of January 8, 1873, concerning certain alterations of the law before cited. (L. G. Bl. No. 5.)

Regulations of the road police for the public roads, not belonging to the state, in Lower Austria, excluding Vienna. (Law of October 24, 1868. L. G. Bl. No. 15.)

Province law for Upper Austria of December 11, 1869, concerning the building and maintenance of roads not belonging to the state. (L. G. Bl. No. 31.) The same for Moravia (L. G. Bl. No. 4, excluding 1869); Styria (L. G. Bl. No. 22, law of June 23, 1866); Carinthia (L. G. Bl. No. 15, law of July 25, 1864); Tyrol and Vorarlberg (law of February 21, 1870, L. G. Bl. No. 16).

A. Classification of the Public Roads.

The different provincial laws classify the respective roads generally into provincial roads, district roads, and community roads.

The following provinces classify their roads differently:

Carinthia, into provincial roads, subventioned roads, and community roads. Styria into district roads first class, district roads second class, and community roads. Bukowina and the coast district, into provincial roads, competition roads and community roads, etc.

Provincial roads are those roads which according to their importance have been declared as such by resolution of the diet; this refers in Lower Austria also to the district roads and in Styria to the first class district roads. District roads (second class in Styria) are those which have been appointed as such by the respective district authorities. All other roads (public) are community roads.

In Bohemia the total length of district roads in 1876 was 12,406 kilometres, and that of the community roads 4,675 kilometres; in 1881 these lengths were 13,492 kilometres and 4,894 kilometres, respectively; so that in the latter year there was an average of 0.260 kilometre of district roads and 0.094 kilometre of community roads per square kilometre of territory.

B. Construction of the Public Roads.

a. THEIR TRANSVERSE SECTION.

The provincial and district roads of Lower Austria as well as the provincial roads of Upper Austria are constructed in the manner of

regular highways, with a width of 6 metres; the community roads, however (Lower Austria), are built according to the requirements of the local teaming, with a width of at least 4 metres, and the smallest roads with a width of 3 metres.

The provincial and competition roads (Tyrol, Dalmatia, coast district) also have a stone foundation and a width of at least 5 metres and at most 6 metres. In Bukowina the roads have a width of 8 metres. The provincial and subventioned roads of Carinthia are from 3.8 to 4.75 wide and in Salzburg the provincial roads are from 4 to 6 metres wide. In Bohemia (see Fig. 4 of the foregoing drawing) the provincial roads, must have a width of from 6.3 to 7.6 metres, and must have a stone foundation of 4.45 to 5.06 metres in breadth and 0.24 to 0.26 metre depth. The covering layer of ballast must be 0.1 to 0.13 metre, which is again to be covered by a layer of sand of 0.03 to 0.05 metre. Bottom width of the road ditch 0.47 metre, convexity of the road surface 0.13 to 0.16, with a width of road of 6.3 and 0.16 to 0.21 metre, with a width of road of 7.6 metre, *i. e.* 1 in 18 to 1 in 24.

For the district roads in Bohemia the following measurements are prescribed: Width of road surface, 5.7 to 6.7, or 3.8 to 4.75 metres; depth of stone foundation, 0.16 to 0.24 metre; covering of ballast, 0.8 to 0.10 metre; top layer of sand, 0.026; convexity, 1 in 21 to 1 in 27; bottom width of ditch, 0.40.

In districts where the stone for the foundation layer would be too expensive to get the road may be macadamized. In such cases the ballast must be put on in layers and rolled until it has reached a thickness of 0.26 to 0.32 metre with provincial roads and 0.21 to 0.26 with district roads. The road must in such cases be provided with bordering stones on either side, in order to prevent the ballast from leaving the road when being rolled.

Provincial and district roads are to be planted with trees in distances of from 20 to 25 metres (Lower Austria, Carniola, Carinthia). In Moravia, if possible, fruit trees must be planted along the roads in distances of 10 metres apart and 0.15 metre distant from the outside border of the road; otherwise these trees are to be planted on the adjoining ground at a distance of 0.60 or at the most 0.65 metre from the outside border of the ditch.

b. Gradient of the Roads.

The gradient of provincial roads (in Bohemia) as a rule must not be any more than $\frac{1}{18}$, and only with very unfavorable territory it may be as much as $\frac{1}{16}$. Steeper gradients are permitted as an exception only on mountain roads, and there only in lengths of at most 95 metres, when these ascents are interrupted by stretches of horizontal or nearly horizontal road.

The district roads of Bohemia are not to have a gradient of more than $\frac{1}{16}$, and with very unfavorable territory not more than $\frac{1}{12}$; steeper ascents are only allowed as an exception on roads for less heavy teaming than the usual, and only by special permission of the board.

c. Maintenance of the Public Roads.

The respective regulations for Lower Austria, to which those of the other provinces are similar, are the following:

The building as well as the maintenance of the provincial roads is incumbent upon the provincial committee, and with district roads to the respective district road board or committee. The proceedings of the latter however are supervised by the provincial committee.

The different communities are obliged to attend to the building and the maintenance of the respective district roads under the supervision of the board or committee for district roads.

If the ballast necessary for the maintenance of the district roads can not be obtained by way of public proposal, or only at a very high price, the committee for district roads has the right to charge the communities with the furnishing of such ballast at a price to be fixed according to circumstances. The costs for carting away the dirt removed from the roads are paid by the district treasury; the communities, however, are obliged to furnish free of cost the dumping places and roads leading thereto. These places must not be farther than 1 kilometre from the respective parts of the road.

The removal of the snow from the roads has to be attended to by the communities, the territory of which is not more than 8 kilometres distant from the road. For this work they receive a proportionate remuneration.

d. Costs.

All costs for the building and maintenance of provincial roads (in Styria) of first-class district roads are paid from the provincial fund.

The costs for the district roads, in so far as they are not otherwise covered, fall to the respective districts, which as a rule are identical with the court districts. The raising of the necessary money is prescribed to the different communities of the district in proportion to their direct taxes (with exclusion of the extraordinary addition tax). A levy of more than 10 per cent. and up to 15 per cent. of the total tax amount requires the permission of the provincial committee, and such of over 15 per cent. can only be imposed by way of legislation. According to circumstances subventions from the provincial fund may be granted for the building, reconstruction, and even maintenance of district roads.

The necessary means and work for community roads have to be furnished by the respective communities. For important community roads, however, subventions from the district road fund are permissible.

The construction of the roadway of a district road with 4.8 millimetres ballasted surface, a stone foundation of 0.20 millimetre, and a bed of ballast of 0.14 costs per kilometre about 3,800 florins, not including the value of the ground and the ground work nor the costs of supervision.

Buildings erected along provincial, district, and community roads

must stand at least 2 metres away from the outside border of the road ditch in Upper Austria, Bohemia, and Carniola; while in Moravia, Silesia, and Lower Austria this distance must be at least 4.7 metres.

For public houses (inns) this distance must be 4 metres in Upper Austria.

STREETS.

The essential rules for the construction of streets in cities and towns are contained in the different building regulations (Bauordnungen; B. O.).

Lower Austria, B. O. for Lower Austria and for the city of Vienna (laws of January 17, 1883, L. G. Bl. 12).

Upper Austria, building laws of March 13, 1875 (L. G. Bl. 7, 8).

Salzburg, B. O. for the city of Salzburg of January 28, 1873 (L. G. Bl. 9).

For the province of Salzburg, excluding the capital, B. O. of July 7, 1879 (L. G. Bl. 10).

Styria, B. O. for Styria, exclusive of the city of Graz, of February 9, 1857 (L. G. Bl. 5); alterations of this law, of August 31, 1864 (L. G. Bl. 2); B. O. for Graz of September 7, 1881 (L. G. Bl. 14, etc.).

A. Construction of city streets and regulations relating thereto.

New streets, if they are principal streets, must be at least 15 metres wide (Lower Austria, Upper Austria, Styria, Carinthia, Moravia, etc.); side streets and lanes must be at least 11 metres wide in Lower and Upper Austria, and at least 12 metres in Prague.

Besides a roadway sufficiently wide to permit the easy turning around of wagons, new streets must be provided on either side with a sidewalk, including which their entire breadth must be at least 15 metres (Graz).

In Vorarlberg the streets in cities and towns must be at least 12 metres wide, in country communities at least 9.5 meters, and lanes at least 8 metres.

In Linz, Wels, Steyer the streets to be considered as principal must be at least 16.20 metres wide, less frequented streets at least 14 metres, and side or cross streets or lanes at least 12 metres.

a. STREETS OF VIENNA.

The total square surface of all streets, lanes, and squares (including the sidewalks, walks, and riding paths) maintained by the imperial city of Vienna at the end of the year 1888 amounted to 5,075,596 square metres. Of these the roadways, squares, crossings, etc., occupy 3,663,740 square metres, or 72.2 per cent., and the sidewalks, walks, and riding paths 1,411,856 square metres, or 27.8 per cent.

Of the entire street surface 3,121,294 square metres, or 61.5 per cent., are paved. Of this paved surface 2,055,181 square metres, or 65.8 per cent., belong to the roadways, squares, crossings, etc., and 1,066,113 square metres, or 34.2 per cent., to the paved sidewalks.

Comparing with the measurement at the end of the year 1887 the paved surface at the end of the year 1888 showed an increase of 55,618 square metres, or 1.81 per cent.

At the end of 1888 the different kinds of pavement in use were in the following proportions:

	Square metres.
Roadways, squares, etc.	
Granite	1,827,276
Asphalt	49,027
Wood pavement	11,030
Gutters and street crossings, granite	167,848
Sidewalks and walks:	
Granite	1,033,275
Asphalt	28,703
Clinker	4,135
Total surface paved	3,121,294

Consequently the entire pavement was composed of:

	Per cent.
Granite	97.03
Asphalt	2.48
Clinker	0.13
Wood	0.36

Of the unpaved surface of 1,964,302 square metres, which are partly macadamized, partly only covered with ballast, 1,608,559 square metres, or 82 per cent., belong to roadways, squares, etc., and 345,743 square metres, or 18 per cent., to walks and riding paths.

Besides the paved surface enumerated there are still of streets, lanes, and squares within the territory of Vienna,

Maintained by—	Paved.	Unpaved.
	Sq. metres.	*Sq. metres.*
The government	49,446	21,372
The provincial fund	72,747	36,361
Private persons	3,200	161,216

Including the above figures the total surface of streets, squares, etc., of Vienna at the end of the year 1888 consequently was: Paved, 3,246,687 square metres, and 2,176,251 square metres unpaved. This total service comprises 1,008 streets, lanes, and squares.

The granite cubes employed for paving the Vienna streets, as a rule, have a length of side of 18.4 centimetres. For the diagonal paving of the roadways there are besides required stones of 13.2 and 23.7 centimetres. Finally, there are also smaller cubes of but 15.8 centimetres side; these, however, are used only in small quantities.

The paving is generally carried out diagonally, and only for streets with a very steep gradient parallel rows are employed.

For the paving of the sidewalks mostly granite plates of 31.6 centimetres and 47.4 centimetres squares are employed.

The greatest part of the granite for paving the streets of Vienna is taken from the quarries at Mauthausen, in Upper Austria. For paving those streets, however, which have an exceptionally great traffic, the hard granite of Wilshofen, in Bavaria, as well as that from Schärding and Dornach, in Upper Austria, are employed.

The clinker pavement, formerly employed by way of experiment on the roadways, has been removed again on account of its inferior durability.

For the asphalt pavement (of natural asphalt) the roadways are covered with pressed asphalt, while on the sidewalks the asphalt is poured over a layer of sand.

By way of experiment the so-called metallic pavement has been tried upon a larger surface. For this purpose a bed of concrete of 10 centimetres is employed, upon which is spread the "metallic" composition 6 centimetres thick for the roadway.

The metallic pavement (furnished by the firm C. Schlimp & R. Scheftel) is a kind of concrete, and consists of broken blast-furnace slag, cinders, and Portland cement; to the water required for mixing this concrete carbonate of soda, carbonate of ammonia, or crude potash is added.

The metallic pavement, the same as asphalt and wood pavement, is noiseless.

B. Maintenance of City Streets.

As most worthy of interest, the facts furnished by the city of Vienna regarding the maintenance of streets will here be given.

The work of maintenance of the Vienna streets as a rule consists in their being repaved, which is done by tearing up the pavement to be repaired and by freshly paving those parts of the street, making use, however, of part of the old material.

The following dates will show the extent of repaving in Vienna:

Year.	Roadway.	Sidewalks.	Total.
	Sq. metres.	*Sq. metres.*	*Sq. metres.*
1884	64,689	16,659	81,348
1885	57,165	10,393	67,558
1886	37,103	8,454	56,557
1888	38,755	7,100	45,955
Five years' average	48,827	10,551	59,378

The ballast used for the maintenance of the respective streets and squares was as follows, in cubic metres, per year:

Time.	Kinds of ballast.							
	Mountain.		Ordinary gravel.	Coarse gravel.	Fine gravel.	Vienna river sand	Sand.	Total.
	Broken	Gravel.						
Five years' average, 1884-'88.	14,952	8,156	5,612	1,122	625	1,505	2,044	34,016
In 1888	13,216	8,222	7,897	977	594	1,456	3,236	35,598

Leaving out the sand, the actual ballast used was 34,972 cubic metres in the average and 32,362 in 1888.

Supposing this total amount of ballast equally divided upon the surface of unpaved roadways, squares, etc., the annual consumption of ballast per square metre of street surface amounts to 0.02 cubic metre.

C. Costs of Construction and Maintenance of City Streets.

The following were the average costs, per square meter, for new paving in the year 1888:

	Florins.
With Vilshofen granite stones	7.70
With Mauthausen granite stones	7.02
With old granite stones	1.06
With common stones	2.81
With asphalt	6.08
With wood	7.44

For the repaving of a surface of 38,755 square metres of roadway and of 7,100 square metres of sidewalks 41,563 florins 78 kreutzers were expended in the year 1888, which is equivalent to an average of 0.91 florin per square metre.

The total expenditure of the city of Vienna for building and maintaining the streets amounted to the following:

Year.	New construction.		Maintenance.	
	Paved streets.	Unpaved streets.	Paved streets.	Unpaved streets.
	Florins	*Florins.*	*Florins.*	*Florins.*
1887	499,710	282	272,438	119,738
1888	408,891	3,760	133,769	130,349
Five-year average, 1884–1888	392,287	26,079	255,170	118,566

The cleaning and sprinkling of the streets in the year 1888 cost for the first district (the central part of the city) 375,928 florins, and for the entire territory of Vienna 908,008 florins.

The total surface of the streets, lanes, and squares kept by the city of Vienna amounting to 5,075,596 square metres, the cleaning and sprinkling of one square metre per year costs 17.9 kreutzer.

D.—Public Parks and Gardens of Vienna.

The following table shows the number, extent, and cost of maintenance of the public parks and gardens of Vienna:

Year.	Number.	Surface.	Cost of maintenance.
		Square metres.	*Florins.*
1887	34	381,473	111,148
1888	35	387,383	123,951

These public gardens (in 1888) amounted to 0.7 per cent., and if the woods are included to 16.7 per cent. of the entire precinct of Vienna, which is 5,540 hectares.

CONCLUSION.

Public streets and roads are universally acknowledged as the prime means of culture, and it is a fact proved by history that the grade of civilization of a nation may in a great measure be judged by the state of its public roads. There is no doubt that the land value is in every country considerably improved by well kept and frequented public roads. It is, however, impossible to express in figures or fix the extent of improvement in value of land intersected by public roads, as this is most everywhere depending on local conditions and circumstances.

JULIUS GOLDSCHMIDT,
Consul-General.

UNITED STATES CONSULATE,
Vienna, April 1, 1891.

TRIESTE.

REPORT BY CONSUL HARTIGAN.

The streets of Trieste, except a few macadamized ones, are paved with sandstone obtained from the neighboring mountains (Karst). This sandstone costs the corporation 2.70 florins per square metre ($1.13 per square yard). The average price of macadamizing stone is 1.45 florins per cubic metre, or 61 cents per cubic yard.

The expense of laying the sandstone, not including its cost, sand, or cartage, is 1 florin per square metre (42 cents a square yard). The labor for macadamized streets costs 80 kreutzers a square metre, or 34 cents a square yard, except the gutter flagging, which costs in addition, 3.25 florins per linear metre, ($1.37 per linear yard).

The maintaining of macadamized roads costs very little. Their average depth is 6 to 10 inches, and the nature of the soil is such that it requires little preparation for a foundation. The maintaining of the paved streets is according to the traffic; the average price, including labor and material, is 50 cents a square yard.

In laying new pavements the old one is placed underneath with a layer of sand intervening, the entire cost of which is 5 florins per square metre ($2.10 per square yard). New streets without this under pavement cost 4 florins per square metre, or $1.78 per square yard, including stone, sand, cartage, etc.

Formerly the streets were laid concave inclining to the middle, along which under the surface canals or sewers extended, with gratings at intervals for surface drainage. It was found, however, from experience

that this plan was not durable for heavy traffic. Accordingly, when new pavements are now found necessary the convex method is adopted. The water from the gutter is conducted by branches to the middle canals or sewers. These latter are also receptacles for overflow pipes from the fecal vaults of the various houses, there being no other sewerage system in the city. The contents are finally emptied along the river or quays of the town.

The streets in general are intended for heavy traffic. The sidewalks are of the same stone, the flags being about 1 to 4 inches thick and 2 to 4 feet square. Their construction and maintenance are borne by the property owners, as well as the stone pillars which line and separate them from the street.

The Trieste sandstone is resisting and desirable material for street paving; the pieces are from 2 to 5 feet long, 1 to 1½ feet wide, and 6 to 10 inches thick.

The roads outside the city are macadamized of the same average depth, and have a stone foundation with open drains on either side.

JAMES F. HARTIGAN,
Consul.

UNITED STATES CONSULATE,
Trieste, January 30, 1891.

BELGIUM.

PROVINCE OF ANTWERP.

REPORT BY CONSUL STEUART.

I have the honor to offer the following report upon the manner of constructing and maintaining the roads and streets in this province and city of Antwerp, and as the said roads and streets are well made and well kept, it would be gratifying if a consideration of the careful manner in which the work is contracted for, executed, and kept in repair should prove of service to those intereste l in bringing about an improvement in the manner and expense of doing these things in our own country.

The thoroughfares in the Kingdom of Belgium are: The routes running from one part of the Kingdom to another controlled and managed by the state authorities; the provincial chaussées, or roads, between two points within a province, constructed and controlled by the provincial authorities; these are paved in the center, a dirt road on each side, and are bordered with trees; the streets constructed and controlled by the municipal authorities.

The provincial council of the province of Antwerp is composed of some sixty members elected from different parts of the province. They

hold one session each year, in the month of July, presided over by the governor of the province, for the purpose of passing the budget, voting subsidies, ordering and approving the construction of roads, canals, etc., and such other matters as may come before them. During the remainder of the year when they are not in session, a committee of their body, consisting of five members, called the "Deputation Permanente," is always in organization, clothed with full powers and prepared to carry into execution the orders and instructions passed by the council, a report being made by them at the next meeting of the council for approval and ratification. Their duties and powers are referred to in the body of the contracts given further on.

Under the rules of the technical service of the province of Antwerp, the service of roadways is intrusted to a body of provincial agents, composed of one engineer-in-chief, three district engineers, and inspectors of roads to a number not exceeding 60.

These agents are charged (in the limits presented by the present rules and in accord with the authorities designated in the legal rules upon the matter) with the service of the district roads, of the works of hygiene, and of the water courses not navigable.

The rules and regulations governing this body of agents are full and elaborate, much too numerous to be translated and embodied in this report, so they are sent in pamphlet form under separate cover.

The streets in the city are all built of the same material and without reference to the traffic that passes over them, whether light or heavy. An idea of their cost can be had from the estimate of expenses making part of the contract for building a street as given below.

As regards the assessment for first cost and maintenance, I can only refer to my dispatch No. 255, dated June 28, 1887, forwarding a full report upon taxation, national and local, in this district, in which occurs the following remarks upon the municipal tax upon sewers and pavements:

The payment of this tax is required but once, and not yearly, even not again when repairs become necessary and are made.

In 1852 the rate was fixed at 12 francs per running metre for all expenses connected with the building of a sewer, and was collected upon the buildings immediately, while owners of unimproved property paid only when they erected buildings thereon; also a tax of 8 francs per metre was collected from buildings upon new pavements, or 5 francs upon old ones, owners of unimproved property paying 2 francs at the time, and the balance when buildings were erected. This law is still in force regarding the property covered by it at that time.

In 1874 the law was changed as follows: For the expense of sewers 12 francs per running metre is collected from the proprietors of improved and unimproved property, and for pavements 10 francs is collected upon the same measurement.

In the laying out of new streets the owners of the property fronting on said streets will be required to bear all the expenses, each in proportion to the number of running metres along the front of his property.

The amount due per metre is found in dividing the cost of the work by double the length of the street, thus covering both sides.

Every six months a map is drawn up for the purpose of showing what new buildings have been erected since the last verification.

Under separate cover and forming part of this report I forward for reference the following documents,* viz:

No. 1. Rules governing the technical service of the province of Antwerp, November 12, 1886.

No. 2. Contract and conditions for the maintenance in good order for a period of five years of the provincial roads of the province of Antwerp.

No. 3. Contract and conditions for the maintenance in good order, for a term of 3 years, of the routes of the state passing through the province of Antwerp.

No. 4. General statement of the conditions governing the work and furnishing of material under the service of the municipal authorities of the city of Antwerp.

No. 5. Contract and conditions for the construction of a chaussée in the district of "Waerloos" in the province of Antwerp.

No. 6. Contract and conditions for the paving and sewerage of the "Rue du Dauphin," in the city of Antwerp.

The two last-named documents have been translated and given below; they furnish the details of the system followed and an estimate of the expenses attendant thereupon.

JOHN H. STEUART,
Consul.

UNITED STATES CONSULATE,
Antwerp, February 2, 1891.

CITY STREETS.

MUNICIPAL WORKS OF ANTWERP.

[Inclosure 1 in Consul Steuart's report.]

Estimates and conditions for the execution of the street works in the Rue du Dauphin (eastern district), Antwerp.

ARTICLE 1.

The object of the present undertaking is the execution by contract of the sewers and pavement of the above-mentioned street, also a water connection with the canal Herenthals.

The work in general shall be executed in accordance with the indications of the plan annexed to the present conditions and with the instructions contained therein. The contractor, in addition, will, in the execution of the works, be held to follow the instructions of the directors.

All the terms and conditions of the general statement of conditions, registered and filed in the fourth bureau, at the City Hall, are deemed to be textually given here, in so far as they are not modified by the following articles:

ARTICLE 2.

The works to be executed consist of:

1. The execution of the works of digging out and filling in, also the leveling, comprising the furnishing of the earth and the work that may be required to brrng same to the prescribed height, and to form the side banks, destined to strengthen the sidewalks; the demolition of the sewers indicated on the plan.

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* Not published.

2. The construction of an ovoid sewer of 14 water pipes with collars for outlets of 14 cast-iron gratings, with ventilators, of the required model and of 11 masoned means of access with cast-iron brinks, comprising the fixtures necessary for draining.

3. The construction of two sections of sewer, paved with flags, in the "longue and courte rue de l'Autel."

4. The work of paving with new stones and the employment in the part of the street destined to vehicles, of new extra large stones (coulants) near the curbs.

5. The work of paving with new stones and the employment for the sidewalks of new borders of cut stone, comprising the joining of the paving in the street and on the sidewalks.

6. The construction of a water connection with the canal Herenthals.

Article 3.

The guiding mark for the leveling forms the tablet of the bridge of the "rue du Canal." This point is situated at a slope of 5.95 metres.

Article 4.

The side banks, which shall strengthen the sidewalks, will be executed along the entire length of the street to be paved, conform to the conditions prescribed, and at the expense of the contractor. This work shall be executed with the earth excavated from other places. These banks will be turfed to a width of 25 centimetres, conform to the instructions of the directors.

Article 5.

The sewer, the stone water pipes, the means of access, and the water connection shall be executed according to the indications of the plan hereto annexed, the prescriptions of the conditions, and the special indications of the directors of the work.

Article 6.

The sewer to be constructed shall have an interior height of 1.30 metres and a width of at most 80 centimetres. Its length shall be 385.70 metres and its frame shall be established at the sides, as shown in the plan.

Article 7.

The concave and convex parts of the sewer shall be formed by two rolls of one-half brick "klampsteen" (ordinary brick) of the kind known by the denomination of "klinkært."

The sewer shall be rough-cast in the interior, up to the commencement of the superior arch, with hydraulic mortar, and the dome of the arch, with the addition of two parts cement.

The centerings shall be properly constructed and strengthened with planks of 2 centimetres thickness; the entire convex surface shall be established in a manner to present a regular curve.

The supports of the centerings shall be placed at a distance of 70 centimetres from axis to axis.

The extrados of the superior arch shall be covered with 1 centimetre's thickness of hydraulic or common mortar.

Article 8.

In the arch shall be established eleven openings, each surmounted by a means of access, having walls of 19 centimetres thickness and an interior diameter of 80 and 70 centimetres. The means of access shall be crowned with a cast-iron brink to conform to the model deposited at the storehouse Leguit.

The contractor shall furnish and place ninety-two collars of cut stone for the outlets of public and private water pipes.

The junction of the sewer to be constructed to that of the Rue du Dragon shall be established in conformance with indications from the directors.

Article 9.

The masonry shall be executed with hydraulic or common mortar. The mortar shall be made under the supervision of an agent of the administration and in a covered place. The mixture of raw materials shall be made in a dry state, then put into a crusher, with the addition of the necessary water.

The directors reserve the right to prescribe the time at which the mixture shall be worked in the crusher.

Article 10.

The contractor shall transport to the storehouse in the Rue St. Gommaire the stones or flags accruing from the demolition of the sewers referred to.

Article 11.

The curbstones, as also the crest of the pavement of the part of the street destined to vehicles, shall be established at the level designated in the plan.

Article 12.

The new sidewalks shall be 2.04 metres wide and the carriage route 7.92 metres. The slope of the sidewalks shall be 8 centimetres.

Article 13.

The paving stones for the street and the stones used for the curbs shall be procured from one of the quarries enumerated under the first category in the conditions. They shall be strictly refused by the administration in case the cutting of the tops is not perfect or does not conform to the prescriptions of the last paragraph of article 28 of the conditions.

The paving stone of the 4th sample shall solely be admitted for the vehicle route, excluding all others. The curbstones shall be procured at the quarries of Quenast or those of Sweden.

Paving stones 6 by 4 (boutisses) shall be placed alternately at the end of the lines.

The paving stones for the sidewalks shall be procured from the quarries of Dinant, of Yvoir, or from the Ourthe, excepting, however, those of Marche and Gernelle; they shall be taken from the best beds and shall be of a uniform blue gray. The dimensions of these stones shall be 14 by 14 centimetres at the top and 10 to 12 centimetres at the bottom, and the height 8 to 11 centimetres. The stones shall have flat tops, even and perfectly smooth, the sides well squared and edged. The paving stones are generally chosen at the expense of the city.

Article 14.

The straight new curbstones shall have a width of 17 centimetres and a height of 30 centimetres; they shall be placed according to the profile indicated in the plan, and each stone must have a length of at least $1\frac{1}{2}$ metres. They shall be procured from the quarries of Ecaussines, Soignies, or Féler.

The curved borders to be furnished and placed number three, of 2 metres and three of 4 metres, radius. The first mentioned shall be composed each of two pieces, 1.20 metres in length, and the others of seven pieces of 1.25 metres in length.

The curved borders shall be 30 centimetres high and 17 centimetres wide at the junctions, and shall have the same profile as the straight borders.

The curved borders shall consist of Swedish or Quenast porphyry.

The joints of the borders, in general, shall be strengthened with mortar.

ARTICLE 15.

In the water way shall be established fourteen sewer gratings, with cast-iron ventilator, similar to the model deposited at the storehouse Leguit.

ARTICLE 16.

The contractor shall take the measures necessary in order to preserve all the pipes serving for the distribution of water and other purposes. In case of an accident, he shall advise the grantee society, who will repair the damage done. The expense arising therefrom will be paid by the city and deducted from the amount retained as guaranty from the contractor.

ARTICLE 17.

The work must be entirely completed within a period of 2½ months.

ARTICLE 18.

The expenses of the undertaking shall be met in three payments.

ARTICLE 19.

The amount of the guaranty to be deposited with the municipal collector is fixed at 2,000 francs.

ARTICLE 20.

The expenses for stamps and registering must be paid into the 4th bureau of the city hall of Antwerp within 8 days after the acceptance of the offer.

ARTICLE 21.

The contractor shall include in the price of his offer a sum of 2,085 francs to cover expenses for watching, plans, and others, which will be deducted from the amount of his offer.

ARTICLE 22.

The envelope containing the offer should bear, under the address of the burgomaster, the words: "Offer for the execution of street works in the rue du Dauphin."

Prepared by the undersigned, engineer of municipal works.

Antwerp, ——— 18—.

(Signed) ——— ———

Seen and presented, Antwerp, ———, 18—.

Engineer and chief director of municipal works:

(Signed) ——— ———

Approved by the "Collège des Bourgmestre et Échevins" of the city of Antwerp in their sitting of ——— ——— 18—.

The burgomaster:

(Signed) ——— ———

The secretary:

(Signed:) ——— ———

Detailed estimate.

Description of works.	Quantity.	Price per unit.	Total amount.
		Francs.	*Francs.*
Excavation, shoving up of earth accruing therefrom, eventual draining, reëmployment of the earth for filling in and damming, comprising the demolition of the sewers designated in the plan, cu. metres..	1,404	1.10	1,544.40
Furnishing and working of the earth in order to bring the street to the required height, comprising leveling and damming..cu. metres..	3,533	.30	1,059.90
Sewer, 1.30 by 0.80 metres........metres..	385.70	15.00	5,785.50
Sewer, 0.70 by 0.50 metre........do ...	20	12.00	240.00
Means of access........cubic metres..	5.500	22.00	121.00
Furnishing and placing of trap doors........kilos..	2,100	.16	336.00
Stone water pipes of 20 centimetres interior diameter........metres..	63	5.00	315.00
Sewer gratings with cast-iron ventilator........	14	75.00	1,050.00
Rough casting with cement mortar of the interior of sewer to 1 centimetre thickness........	826	1.00	826.00
Cut stone for outlets of public and private branchings off; 92 x 0.45 x 0.45 x 6.30 cubic metres........	5.575	120.00	669.00
New straight curb stones........metres..	550	6.00	3,300.00
New curved curb stones........do ...	27.10	13.00	352.30
Pavement with new stone 8 by 4 for sides........square metres..	92.32	13.00	1,200.16
Pavement with new stone for street........do....	2,431	7.00	17,017.00
Pavement with new stone for sidewalk........do....	1,079	6.00	6,474.00
Old curbstones, taking up and placing........metres..	10	.30	3.00
Pavement with used stones for sides........square metres..	1.60	.80	1.28
Pavement with used stones for sidewalks........do....	20	.80	16.00
Pavement with used stones for streets........do....	150	.35	52.00
Transportation of flagstones to storehouse of the city........	....	....	75.00
Establishment of the water connection with the canal Herenthals:			
Foundations in rough masonry........cubic metres..	1.650	12.00	19.80
Masonry........do....	13	22.00	286.00
Furnishing and placing of cut stone........do ...	2.027	120.00	243.24
Wrought iron for grating of the 2 mouths of the water connection comprising sealing with lead........kilometres..	40	.40	16.00
Cast-iron trap doors of 80 by 80 centimetres........do....	450	.16	72.00
Expenses for guards, plans, etc........	....	....	2,085.00
Expenses for stamps and registering........	....	....	24.92
Total........	....	....	43,185.00

Drawn up, with an estimate of the sum of 43,185 francs, by the undersigned engineer of the municipal works.

Antwerp, ——— ——, 18—.

(Signed,) ——— ———.

Seen and approved, Antwerp, ——— ——, 18—.

Principal engineer, director of municipal works:

(Signed,) ——— ———.

MODEL OF OFFER.

I, the undersigned (full name), contractor of public works, residing at ———, street ———, No. ——, bind myself by the present, upon guaranty of my personal and real property, to execute under the terms and provisions of the contract and special conditions, according to the prescriptions specified and conforming to the plan, of which I declare to have a perfect knowledge, in consideration of the sum of (to be written out in letters), the street works in the Rue du Dauphin.

Done at ———, the —— day of ———, 18—.

COUNTRY ROADS OR HIGHWAYS.

[Inclosure 2 in Consul Steuart's report.]

PROVINCIAL GOVERNMENT OF ANTWERP.—TECHNICAL SERVICE.

Statement of the stipulations and conditions upon which will be awarded the construction of a chaussée or wide carriage road following the route No. 3 at Waerloos.

DESCRIPTION OF THE WORK.

ARTICLE 1.

The undertaking comprises:

1. The execution of the earthworks.
2. The construction of the "ouvrages d'art" and the furnishing of the necessary material.
3. The paving.
4. The maintenance in good order for 1 year of the chaussée and its dependencies.

ARTICLE 2.

The road to be constructed shall be laid out according to the trace in red upon the plan annexed to the present contract and conditions; it will commence at a given point in the village of Waerloos; will extend along the road No. 3 to join the direct chaussée from Waerloos to Duffel near the limits of the latter village. The total length of the chaussée is to be 1,917.50 metres.

ARTICLE 3.

The red line running lengthwise along the plan of the chaussée shows the height at which will be established the crest of the paving.

The system of slopes and borders shall be made conformably to the indications of the profile lengthways.

The slopes and borders shall be joined to each other in the vertical sense by regular curves of which the development will be indicated by the provincial engineer.

The route shall have 6 metres of width between the outside crusts of the sideways; the paved part will occupy the middle part of the route and will have 2.50 metres of width.

The convexity of the paving shall be 97 centimeters, and the transverse inclination of the sideways shall be .04 centimetre per metre.

The route shall be bordered with ditches having 1 metre width at the top and 40 centimetres depth. These dimensions may be modified according to the requirements of the ground.

The crests of the sideways shall be marked by level borders of grass of 25 centimetres width with 8 to 10 centimetres thickness.

ARTICLE 4.

The plan of the work shall be executed by the contractor or his agents under his responsibility. The work, however, can not be commenced until after the plan has been verified by the provincial engineer.

All the tools, utensils, engines, wheelbarrows, carts, etc., in fact all the material necessary for the carrying on of the work, without any exception whatever, must be provided by the contractor.

The works will be commenced at the points designated by the provincial engineer.

Article 5.

The earth coming from the excavation and that necessary for the embankments shall be employed to form the profiles of the roads following the sides; the same earth shall serve to unite roads, avenues to farms, or entrances to fields with the sideways of the route.

The earth removed, with the exception of mud, roots, and grass shall be employed in the work of filling up and embanking.

If the ground coming from the excavations is not sufficient to meet the requirements of the embankments the contractor must provide the quantity needed.

Article 6.

After all the preliminary earthworks have been finished a coffer shall be opened at a depth of 25 centimeters, preserving at the bottom a slope or convexity equal to that of the paving. The bottom as well as the sideways shall be made thoroughly strong.

The bed of sand will have a thickness of 25 centimetres, measuring from the top of the pavement.

Article 7.

Paving.

The borders shall be placed along the line following the slopes, declivities, and levels as indicated. They shall be joined and made firm at the outside with sand well driven in.

The space between the two border lines shall be filled with paving stones forming a regular connection, placed in such a manner as to touch each other on all sides, the joints well filled with sand and made firm under the weight of a hammer of at least 6 kilogrammes.

The stones shall be successively driven firm with a paving beetle weighing at least 16 to 18 kilogrammes.

The hammering shall commence at the borders of the chaussée and be continued towards the axis, taking care to preserve the slopes and convexity indicated upon the plan.

The hammering shall be done regularly by two workmen, commencing one from each side of the route and advancing towards the axis, hammering the same line of stone.

All the stones which may be broken under the weight of the beetle, or which may be driven below the surface line, shall be removed and replaced by others having the proper dimensions to be fitted to those already placed.

When the supervisor of the works shall be satisfied that the paving has been well done, there shall be spread upon it a bed of sand 2 centimeters deep.

Article 8.

The operations of the plan and the verification of the work shall be at the charge of the contractor, who will furnish for this purpose the workmen and the instruments necessary, such as squares, levels, chains, lines, stakes, etc.

Article 9.

Travaure d'Art.

The framework of the "Travaure d'Art" shall be made firm to the sides of the level marked in the special plans.

These works of art shall be constructed under the best conditions conformably to the plans, and after the indications of the provincial engineer.

These works are:

One aqueduct with 80 centimetres opening, square section, and covered with flagstones.

Three aqueducts of 30 to 35 centimetres opening, section rectangular, and covered with flagstones.

ARTICLE 10.

The compensation due to third parties for the taking of sand, earth, depots of materials, shops, service roads, etc., will be at the charge of the contractor.

In no case will a depot of materials be allowed upon the ground reserved for the bed of the route or its dependencies.

ARTICLE 11.

Materials.

The paving stones shall be in porphyry or sandstone.

The contractors must indicate in their offer the kind (porphyry or sandstone) and the place of production of the paving stones that they agree to place in the work.

The administration reserves the right to choose, as best suits them, among the different offers.

The paving stones shall have the following dimensions: Length, 14 to 16 centimetres; width, 14 centimetres; height, 14 centimetres at the least.

The borders of the chaussées shall be in ordinary limestone granite. They shall have the following dimensions: Length, 26 to 36 centimetres; width, 14 centimetres; height, 25 centimetres.

Sand: The sand shall be pure, dry, gritty, free from stones and clay.

Lime: The lime shall be of the best quality, and shall be furnished "quick" at the foot of the work.

Bricks: The bricks shall be of the kind called "Klampsteen." They must be well formed, well burnt, hard, and sonorous. The bricks for the facing shall be chosen from among the best looking and the best burnt. They shall be of uniform color.

Bluestone: The bluestone shall be of the ordinary limestone granite. It shall be taken from the largest and hardest quarries. It shall have neither flaws, thin places, broken corners, or defective veins.

The facings shall be finely cut. The tablets shall be provided with drains.

Flagstones: The flagstones shall be of stone from "Tournai." They shall be of best quality and have a uniform thickness.

Mortar: The mortar of the ordinary masonry shall be composed of two parts of slack lime, one part of ashes, and one part of sand.

That for the rough casting of the "Ouvrages d'Art" shall contain three parts of lime and two parts of "trass," which is a rough cement.

ARTICLE 12.

Nature and reception of material.

All of the material, each of its kind, shall be of the best quality; it must be delivered at the works, but can be employed only after having been accepted by the administration. It must be placed in such a manner that its verification may be as easy as possible.

The contractor must furnish the workmen necessary for the reception of the material.

The material rejected must be immediately removed from the works and replaced by others, and that before the resumption of work.

Article 13.

General conditions.

The present enterprise constitutes an absolute contract, consequently the contractor shall be held for in consideration of the price of adjudication, to execute, at his expense, risk, and peril, and to deliver, at the expiration of the contract time, all the works which make the subject of this contract and which are mentioned or described in the present conditions or appear upon the plans hereto annexed, in furnishing and putting upon the work all the materials necessary to this effect and in conformity with all the clauses and provisos stipulated in the said conditions.

The contractor shall be considered to have established the sum total of his offer after his proper calculations and estimates; he will not be permitted to raise any claim by reason of errors or omissions which might appear in the measurement and detailed estimates, which are joined to the conditions only as simple suggestions, and of which the quantities are not guarantied.

The administration formally reserves to itself the right to prescribe to the contractor, in the execution of the work, such modification as they may judge proper to make in the work as provided for, whether in regard to the form, the dimensions, or the method of construction, or in regard to the nature of the material to be used in the work, or in any other manner, and this without the contractor being able, by virtue of this matter, to raise any complaint or claim whatsoever.

Should the case occur, the administration will prepare a statement in which the works, as provided for, that the contractor will be relieved from executing and those that he must execute, not previously provided for, will be valued at a price greater or less, as may be, pro rata of the difference between the total amount of the detailed estimates and that of the adjudication.

The contractor will be held to accept the statement which will have been prepared by the Direction, unless objections and claims on his part may be considered as well founded, whether in regard to the price at which the work is valued or in regard to the quantity of the work which has been carried into the statement, in which case a new statement will be prepared, giving right, if necessary to his claims, and that the contractor can no longer refuse to accept.

Article 14.

No work not provided for, either on the plan or in the present contract and conditions, shall be allowed to the contractor, if the execution has not been previously authorized by the administration.

The work will be considered to have been done in the interest of the contractor and will remain at his expense.

Article 15.

The contractors are not allowed, except in cases of necessity and pressure, to make the workmen work on Sundays or legal holidays, or to admit upon the works children under the age of 13 years.

The infraction of these rules will be ascertained by the provincial engineer or his subordinates charged with the supervision of the works, by the communal administration, and by the agents of the local police.

The contractor will be liable to a penalty of 5 francs per day, to be retained from the amount of the adjudication, for each workman who will have worked on Sunday or a legal holiday and for each child under 13 years admitted upon the works.

In case of dispute as to the real infraction or as to the amount of penalties applied the contractor will be allowed to appeal to the députation permanente and he must submit to their decision.

The amount of penalties imposed shall be granted by the députation permanente to the bureau of charity of the commune where the infraction occurred or to a hospital if one exists in the locality.

ARTICLE 16.

Commencement and completion of the work.

The contractor shall commence the work within 10 days of the order that he shall receive from the administration; the work must be entirely finished the 1st of November, 1890, period at which it will be submitted to a provisory reception.

The reception shall be in the presence of the commission and shall be verified by a regular official report.

ARTICLE 17.

In the case where the contractor, by carelessness, ill-will, or lack of means shall refuse to comply within 10 days to the orders which may be given to him by the provincial engineer, the work will be proceeded with and the expenses resulting therefrom shall be deducted from the payment of the last quarter of the enterprise.

ARTICLE 18.

Fines and forfeits.

For each day of delay beyond the time established the contractor shall be liable to a penalty of 20 france per day; if this delay reaches 30 days, on the 31st day the contractor shall forfeit all his right to the undertaking and all expenses resulting therefrom shall be at his charge.

ARTICLE 19.

Delay.

The députation permanente alone accords an extension or delay in the finishing of the work. It alone also inflicts the penalties after having heard the province and the contractor interested.

The penalties that the contractor will have incurred shall be turned into the provincial treasury.

ARTICLE 20.

The contractor will be held to guaranty his work for the term of 1 year from the time of the legal provisory reception; he will keep it in perfect order during that lapse of time.

At the expiration of this time and before the route be recovered with a bed of sand 2 centimetres in thickness, the final reception shall take place.

Works left in suspense shall be executed officially and their cost be withheld from the amount of the 5 per cent. held for guaranty.

The final reception will take place in the presence of the commission and will be verified by a regular and detailed legal report.

ARTICLE 21.

The contractor can not, in any case, give over his undertaking to any one whatsoever, without the consent of the administration; the subcontractors that he may associate with himself will not be recognized by the administration.

Article 22.

All infringements of the stipulations contained in the present conditions will be verified by the provincial engineer; the legal documents will be prepared in duplicate, of which one will be delivered at the real or chosen residence of the contractor against a receipt signed by him.

The same mode of delivery will apply to other acts of which the notification must be verified in an official manner. In case of the absence of the contractor or his proxy, or upon the refusal to deliver the receipt, the delivery can be made at the residence, either by a registered letter through the post, at the expense of the contractor, or by the declaration of an agent of the direction establishing the delivery of the documents at the residence of the contractor.

Article 23.

All differences arising between the province, the provincial engineer, and the contractor shall be submitted to the commission, reserving appeal to the députation permanente, to whose decision the contractor must submit without further recourse.

Article 24.

Payments.

The payments will be made quarterly, in proportion to the advancement of the work, reserving the amount of 5 per cent. to serve as guaranty and which will be paid at the final reception of the work, deduction having been made for the amounts officially expended, of which mention has been made in Article 17.

The payments will be made in cash upon the certificates delivered by the provincial engineer verifying the portion to which the contractor is entitled. All payments made within 8 days following the delivery of each certificate will be considered as cash.

Fifteen days before the estimated time of the delivery of each certificate the provincial engineer of the roads shall inform the commission of the delivery of this piece to the contractor.

In case of delay in payment, there shall be 5 per cent. interest due to date from the eighth day after the emission of the certificate of reception, of which the contractor shall receive an official notice for his guidance.

Article 25.

Indemnities.

No indemnity shall be allowed to the contractor on account of losses, injuries, damages caused by negligence, want of means, or bad workmanship, unless it can be established that the injuries or delays came from a superior power and were independent of his will.

The contractor will be allowed to plead the superior power, whether for a claim of indemnity of any kind whatever, or to justify the nonexecution of any part of the work, or to obtain a remission of all or part of the penalties that he had incurred, only in case that, within 10 days of the circumstances or events from which may have resulted the obstacles or damages, he will have made known the situation to the administration.

Article 26.

The contractor shall comprise in his offer—

1. A sum of 1,134$\frac{31}{100}$ francs for works unforeseen.

2. The expenses of printing, of advertising, of posters, of stamp and registering the conditions and legal contract of adjudication, valued at 200 francs.

The payment of these expenses shall be made within 8 days following the approval of the legal contract.

3. Three per cent. upon the total of the amount of adjudication to the profit of the province.

ARTICLE 27.

Security.

In order to take part in the adjudication the competitors must deposit in the national bank the sum of 4,000 francs either in cash or national bonds.

The receipt for the deposit must be annexed to the offer. Any offer to which this receipt is not annexed will not be considered.

The restitution of the deposits to the unsuccessful competitors will be made, with the authority of the governor of the province, immediately after the approval of the adjudication.

The amount deposited by the one obtaining the contract will remain in the national bank as security until the temporary reception of the work.

ARTICLE 28.

Method of adjudication.

The assignment will be made upon the offers addressed to the greffier (notary) of the province of Antwerp, by registered letters placed in the post at least 1 day before the date fixed for the adjudication.

The greffier, assisted by the delegates of the communal administration and chief engineer, will proceed to the opening of the offers in public session.

The offers, which shall contain stipulations other than those provided for in the given conditions, will not be considered.

The offers and the legal copy of adjudication will be submitted to the approval of the common council, and if necessary to that of the députation permanente.

Prepared by provincial engineer.

Antwerp, April 16, 1890.

(Signed.) ——— ———.

Seen and presented chief engineer, director.

Antwerp, April 17, 1890.

(Signature.) ——— ———.

FORM OF OFFER.

I, the undersigned (full name), contractor of public works, living at ——— street, ———, No. ——, do engage by this offer, under guaranty of all my property, real and personal, to undertake, upon the terms and provisions of the contract and conditions, all the work for the construction of a chaussée following the route No. 3 at Waerloos, in consideration of a sum of (indicate the amount in writing and in letters), putting on the work paving of the fourth sample (indicate the kind and origin of the paving stone).

Made at ——— ———, the —— day of ———, 18—.

(Signed.) ——— ———

DISTRICT OF WAERLOOS.

Estimated expense of works to be executed in the construction of a carriage road following the route No. 3:

Description.	Dimensions.			Quantity.	Price.	Amount.
	Length.	Width.	Height.			
	Kilos.	*Hectos.*	*Dekas.*		*Frs.*	*Francs.*
Earth works:						
Excavation, filling in, and transport of earth.				1,917.50 meters	0.60	1,150.50
Digging ditches				3,446.00 meters	0.15	516.90
Turfing the ridge of the sideways	3,446.00	0.25		861.50 square meters.	0.20	172.30
Digging the coffer and furnishing the sand.	1,917.50	2.50	0.25	1,198.44 cubic meters.	0.75	898.82
Working up the profile of the sideways.				1,917.50 meters.	0.15	287.63
Repairs of the earthworks				1,917.50 meters	0.10	191.75
Paving:						
Pavings of 0.14 by 0.16 (porphyry or stone) and borders, 4-inch sample, common limestone granite.	1,917.50	2.50		4,793.75 meters		
Joining to the road				75.00 meters.		
				4,868.75 meters	6.70	32,620.63
Repairs of pavement				4,868.75 meters.	0.10	486.88
Travaux d'art:						
Aqueduct, 0.80 by 0.80 meter section.				1 piece		543.96
Aqueduct, 0.30 by 0.35 meter section.				8 pieces		876.32
Boundaries in cut stone				80 pieces	1.50	120.00
						37,865.69
For work unforeseen						1,134.31
Expenses of registering, printing, adjudication, etc.						200.00
						39,200.00
3 per cent. to profit of the province						1,176.00
Total francs						40,376.00

The present estimate amounts to the sum of 40,376 francs.
Prepared by provincial engineer:
(Signature.) ——— ———
Antwerp (Date).
Engineer-in-chief, director.
(Signature.) ——— ———
Antwerp (date).

HIGHWAYS IN BELGIUM AND IN THE UNITED STATES.

REPORT BY CONSUL TANNER, OF LEIGE.

[From Consular Reports No. 24.]

While the Department of State is making such laudable efforts for the extension of our commerce and industry it behooves us not to lose sight of matters at home equally conducive to our prosperity.

In order to lay clearly and concisely my subject before the Department I will do so by presenting two pictures.

PUBLIC HIGHWAYS IN BELGIUM.

Americans who find themselves in Europe are struck with astonishment at the enormous loads drawn by horses and dogs here. One glance of the eye from the bulk just mentioned to the roads and half the wonder would be accounted for, because the roads have almost everything to do with it. We are too apt to ignore that which we trample under foot. The ancients knew and appreciated more the importance of good public roads than we do to-day, though at the present time in Europe this is a subject of first importance.

Many of the roads built by the ancient Romans and traveled by the proud Roman conquerors remain to this day. This is particularly the case in Turkey, where they have, ever since the Roman era, been in use with little or no repair. Of the numerous evidences left by them of their greatness and civilization I deem these roads the seal and stamp.

Belgium is divided into nine provinces, and each province is the seat of a well-organized State government, presided over by a governor. Each of the nine provinces, at each seat of government, has a bureau for roads and bridges whose chief gives his undivided attention to these things.

The roads are most carefully engineered in the first place, heavy grades, even in mountainous localities, being carefully avoided. The roads are built in an oval form, and in most cases are paved with stones; in others gravel forms the road bed, and still in others gravel covers the stone, which, soon becoming hard and smooth, makes the best road bed of all others, because the jolts and noise of a paved road, which are both tiresome and disagreeable, are avoided, and then the wear and tear are not so great on the running gear, and this kind of road is decidedly more agreeable to pedestrians and possesses, in addition to other advantages enumerated, the advantage that if the gravel washes away the stones remain and a good road is always assured.

The stones composing the roads are of a blunt wedge shape, 4 or 5 inches square, and are quickly laid and quickly taken up if necessary. These stones are uniform and regular in size, and, when placed, dirt is placed over the new pavement and then a large roller, drawn by four horses, is passed and repassed over it until the stones are well settled in their places and the crevices filled with earth. In constructing roads here regard is always paid to locality and liability to wash. Where there is no danger of washes stones are dispensed with altogether and an oval-shaped gravel road substituted at less cost, but in all cases the sides of the road receiving the drainage and where it is apt to show first symptoms of yielding to bad weather are carefully paved so that washes and gullies can not commence in that quarter.

These roads are flanked on either side by two, and sometimes four, rows of shade trees, which add much beauty to the country through which they run, and from a distance are particularly picturesque where several roads intersect. One can mark the roads in their windings sometimes as far as the eye can reach by these fresh green shade trees, which, with the various teams of horse and dog laden with the products of farms, mines, and shop, conspire to make a very pretty scene. I never look at these roads but what I think of the enormous blessing and luxury they would be in certain sections of our country.

The public roads of Belgium enter into successful competition with the railroads, so much so that a man who has his team does not by any means consider himself forced to send his products by rail. It is one of the commonest of sights here in Liege to see wagons laden with merchandise from Brussels, which is 60, or from Antwerp, which is 72, miles from this place; this fact does not possess anything astonishing until the enormous loads pulled that distance by one horse is considered, and there is nothing that so astonishes the American as this. Sometimes the wagon itself looks like a sufficient charge for two horses, while wagon, load, and all are drawn by one with the greatest ease. Those horses are of a larger and stronger build than our horses, and from their size and strength are called in England "En-

glish drafts." Place the same load on almost any of our roads in the United States, and at least two more, if not three more, "English drafts" would be required to pull it the same distance. Dog carts come to this market, laden with beef and other products of the farm, a distance of 12 and 15 miles, drawn by one dog. Two grown, persons return in the wagon.

AMERICAN HIGHWAYS.

In presenting the other side of the picture the task is not an agreeable one because I will have to write some very disagreeable things. Can it be said that we have any public roads in the United States? I have only made the acquaintance of the public roads in the Western and Southern States, and there is only one within my knowledge that can make pretentions to being called a road in the Belgian sense, and that is in the Valley of Virginia. Most of the others that have come under my notice are little short of bogs, swamps, and marshes, and the bridges man-traps. These roads are utterly at the mercy of the weather, and are passable or impassable according to it, and are entirely out of keeping with the enlightened and intelligent people who, through apathy, patiently endure such a state of affairs.

I have been in certain sections of the South, in the fall and winter months, when the farmer had gathered his crop, and when the business season would naturally be good, when the farmer would go to market, make his sales, and return with merchandise and heard the most dismal complainings of dull business and "hard times." This is the case simply because in most cases the roads are utterly impassable, the distribution of products is at a standstill, and of course dull business follows. There are few outside of these sections that know the real condition of these roads. The emigrants, however, know more on the subject than many Americans, as I will show further on. I have been on the roads and seen a poor old Rosinante tugging away at a wagon stuck in the mud almost out of sight; when released from his gear he could hardly pull himself out of the mire. Some of these roads are marked with skeletons of horses that have been beaten to death or drowned in the mud or some bridgeless stream, and wrecks of wagons and other vehicles mark the place of an accident to some one who had courage enough to venture out on the road. I was in one of the most beautiful of our Southern cities last winter, and while there read a glowing account in one of the newspapers of the place of a horse having been smothered in the mud, and this on one of the principal streets of the city. When poor roads prevail in a section, everything else is very apt to be poor—the horse, the farmer, and the merchant, and the church.

Where good roads prevail you find a community that would be loth to give them up.

It is a well-known fact that in spite of the strenuous efforts made in some sections of our country to induce emigrants to settle among them, very few accept the invitation. I am in a position here to know something of the emigrant. He generally posts himself pretty thoroughly about a section before he goes to it. This is made easy by the numerous emigrants who have preceded him, and he is sure to have acquaintances in several sections who give him information. I have invariably been informed by them that they would not go to a section where the roads were impassable. This is their only objection. They inform me that they would gladly go to such sections, but that they do not wish to be mud-bound or mud-blockaded for six months in the year. I can say to such sections that they must make good public roads before they can induce emigrants to come among them. If it is economy that restrains, it is a false economy; every day that they allow their public roads to remain in an impassable condition, their streams to remain without bridges, they deal a direct and severe blow at their own interests; the country will remain undeveloped, its hidden treasures locked up. These roads, if improved at once, newly engineered, and made good roads, with permanent bridges that could not be swept away with every rise in the stream, would give some sign of permanence of settlement, and of contentment with the section; the burden of the tax would soon be shared by so many that the roads

would not only be self-sustaining, but would be a source of revenue to the State. The taxes would return in the improved condition of stock and running gear, and of the increased loads that could be sent to market in wagons. Circulation, which is the backbone of business, would be facilitated; where now it is a hazard and a task to venture on the public highways it would become a pleasure. In short, there are few blessings that any community can know equal to that of having first-class roads. But unless roads are made first-class, to commence with, you will never have them, and you throw away the money you invest in them.

GEO. C. TANNER,
Consul.

UNITED STATES CONSULATE,
Liege and Verviers, August 1, 1882.

BRUSSELS DISTRICT.

REPORT BY CONSUL ROOSEVELT.

STREETS.

Owing to the numerous quarries existing in Belgium, very little else than stone is employed in paving the streets and highways, in and around Brussels. A few streets in the center of the city, as well as the sidewalks of the railway stations, are paved with condensed asphalt, coming from Val de Travers. On account of the peculiar situation of the city, the majority of the streets are of too precipitous an incline to permit the successful condensation of asphalt. Wood paving is employed on some of the boulevards.

Asphalt paving.—Streets destined to receive asphalt are constructed in the following manner: The soil is removed to a depth of 6 inches, the ground then leveled into shape, preparatory to receiving a deposit of concrete, composed of Portland cement and gravel, upon which the asphalt is applied to a depth of 2 inches. The method of laying wood pavement is similar to that employed in the United States.

Stone paving.—Primary preparation of streets to be paved with stone is identically the same as when asphalt is employed. A deep bed of sand is, however, deposited instead of concrete, upon which paving stones, known as Belgian blocks, are placed in transverse rows, and firmly fixed in a smooth and comparatively compact mass, by use of a heavy paving ram worked by hand, a slight sprinkling of sand is applied and the street declared ready for traffic.

BOULEVARDS.

The boulevards of Brussels, forming a continuous and beautiful circuit around the city, are abundantly planted in fine, large elms, maples, sycamore, and chestnut trees, affording delightful promenades to pedestrians and equestrians, as well as fine carriage drives.

The boulevards vary in width according to section of city which they traverse. They are divided into roadways for tramcars and heavy

traffic, walks for pedestrians, and roads for carriages and equestrians. The walks devoted to pedestrians are constructed from pulverized granite covered with a sufficiently deep layer of sand rolled hard and smooth, and afford agreeable promenades even in wet weather. The roads are built on similar principles as ordinary roads, that is, the ground is excavated to an agreed depth, say from 10 to 16 inches, and filled in with the paving material. The roads devoted to equestrians are filled in to a depth of 16 inches with broken brick, which after being leveled into shape is covered with a thick bed of sea sand. The carriage roads are paved in part with asphalt, wood, and also broken and pulverized granite, the latter producing a fine macadamized roadway.

The pavements and paving stones, their origin, duration, and cost are as follows: Porphyry, from quarries at Quenast and Lessines, estimated duration 75 years; sandstone from quarries at Ecoussines, estimated duration 60 years. No. 4 from the vicinity of the rivers Ourthe and Meuse, estimated duration 40 years; limestone, no longer accepted by the city government, estimated duration 25 years.

Porphyry, per square yard, 9.50 francs ($1.83); sandstone, per square yard, 8.50 to 9.50 francs ($1.64 to $1.83); asphalt from Val de Travers, per square yard, 17 francs ($3 .27); wood on concrete foundation, per square yard, 11 francs ($2.12); the two last named pavements are highly esteemed and much employed on the boulevards.

HIGHWAYS.

Roads in Belgium are divided into three categories and distributed under the following administrations:

1. Government roads under the administration of bridges and roadways (civil engineering).
2. Provincial roads, controlled by the provincial government.
3. Communal roads, controlled by the communal authorities.

Dimensions.—Government roads: Width of roadway, 5 yards 20 inches; width of sidewalk, 2 yards 8 inches; width of ditch, three-fourths yard.

Provincial roads: Width of roadway, 5 yards 20 inches; width of sidewalks, 2 yards 27 inches; width of ditch, three-fourths yard.

Communal roads: Width of roadway, 4 yards 16 inches; width of sidewalk and ditch, 1 yard 24 inches.

Materials.—These roads are paved with native porphyry and sandstone of following dimensions: 7 by $6\frac{1}{4}$ inches, $6\frac{1}{4}$ by $5\frac{1}{2}$ inches, $5\frac{1}{2}$ by $4\frac{3}{4}$ inches, $4\frac{3}{4}$ by $3\frac{1}{2}$ by $8\frac{1}{2}$ by 7 inches, $4\frac{3}{4}$ by $3\frac{1}{2}$ by 7 by $5\frac{1}{2}$ inches. Curbstone, 30 by 15 inches each side of road.

Cost of construction of road destined for frequent and heavy traffic, per square yard.

Preparing bed 12 inches deep	$0.03
Ashes	.09
Paving stones 6½ by 5¼ inches	1.31
Labor	.04
Total	1.47

Ashes per cubic yard 30 to 40 cents; sand per cubic yard, 48 to 58 cents.

With rough or broken stone.

Preparing bed 12 inches deep	$0.03
Rough stone, 8 inches deep	.16
Broken stone or pebbles, 2 to 4 inches deep	.11
Labor	.04
Contractor	.03½
Total per square yard	.37½

Cost of maintenance.—Country roads, per running yard, 4 cents; near industrial districts, 6 cents; proximity to sugar factories, 6 to 10 cents.

Roads are annually inspected and repaired as follows:

From 25 to 20 consecutive yards out of every 4,000 or 5,000 yards of pavement are taken up and replaced by new material. On roads devoted to heavy traffic, paving stones 7 by 6½ inches are employed, as also on inclines averaging less than three-fourths of an inch per yard. On inclines averaging more than three-fourths of an inch per yard, stones 6¼ by 5½, or heavy oblong stones 4¾ by 3½ by 8½ by 7, are employed. Where the soil is very firm, sandstone blocks 7 by 6¼ inches are preferred, which, with heavy oblong stones, are also used on inclines according to declivity. Satisfactory drainage is produced by depositing a deep bed of ashes prior to placing pavement. On roads of light traffic blocks 4¾ by 4¾ inches are used on the level. While 4½ by 3½ and 6½ by 5 inches are employed on inclines.

Contract for keeping roads in repair is by public bid, and is awarded to lowest bidder for a term of three years, the average cost of repairs to roadway 5 yards, 20 inches wide, as follows: Porphyry blocks, per square yard, 6 cents; sandstone per square yard, 5 cents. The value of land lying near or adjacent to improved roads is increased according to proximity to some large city or industrial center.

GEO. W. ROOSEVELT,
Consul.

UNITED STATES CONSULATE,
Brussels, February 23, 1891.

FLANDERS.

REPORT BY CONSUL OSBORNE, OF GHENT.

I. CITY STREETS.

The material and its sources.—The exclusive paving material for all the towns in the provinces of East and West Flanders, indeed, practically of the entire kingdom, is Belgian blocks. These are of sandstone of different degrees of hardness. There are three recognized varieties. First, those from Ecoussines, province of Hainaut, which are of medium hardness and smoothness. It is these quarries which supply most of the paving material. The same locality also furnishes a blue limestone, sometimes called Flemish granite, which is cut into slabs and used for the curbstones. Second, those from Quenast, province of Brabant, which are very hard and smooth. Lastly, those from the neighborhood of the river Ourthe, province of Liege, which are least hard and rather rough. Superior blocks for sidewalks are obtained from Lessines, in Hainaut.

Methods of building and maintaining.—The paving stones are generally in cubic form, but lately rectangular ones are preferred. There are eight sizes used for paving, of which I give below the dimensions of the five principal ones. Numbers 3 and 4 are those used in Belgium, especially the latter. The largest size is only used in large cities.

Dimensions.	No. 2.	No. 3.	No. 4.	No. 5.
	Inches.	*Inches.*	*Inches.*	*Inches.*
Paving blocks:				
Length	7 to 7.8	6 to 7	5.7 to 6	4.7 to 5.7
Breadth	7	6	5.7	4.7
Thickness	7	6	5.7	4.7
Blocks for border:				
Length	11.8 to 15.7	11 to 15	10 to 14	9.4 to 13.4
Breadth	7	6	5.7	4.7
Thickness	13.7	11.8	9.8	7.8

The process of laying the pavement is simple. First, the soil is removed to a convenient depth and the "form" is prepared by leveling the ground in the shape it will have when the pave is completed. A bed of sand to a depth of half a foot is then deposited. On this the blocks are laid in transverse rows conveniently close together, the joints always coming to the middle of those of the contiguous rows. Next, they employ an iron paving ram weighing about 35 pounds, and worked by hand. With this they strike each stone, strengthening and smoothing the whole. Lastly, a thin coating of fine sand is put on, which gradually penetrates the crevices. The street is then ready for use.

The stones for the border are somewhat larger, as shown in the above table, than the other blocks. Next to these come the curb-stones, which are of varying dimensions and are placed upright, the top level with the sidewalk.

The sidewalks are constructed similarly to the roadway, except that the blocks are usually superior and cemented together.

The pave is a durable one and few repairs are necessary even on a street of heavy traffic. However, when they are made it is a simple matter, generally the readjustment or substitution of a few blocks.

The streets are kept scrupulously clean, usually by hand. In Ghent sweeping machines traverse the principal streets at night. The city government has charge of this work.

Cost of construction and repairing.—The cost of construction varies from $1.04 to $1.21 per square yard for the ordinary size of block No. 4, the materials being included.

The expense of repairs averages from 2 to 4 cents per square yard.

Both the building and repairing are at the expense of the city. No special assessment is levied, but it is included with other public improvements. On the contrary the expense of the sidewalks is upon the property-owners.

Character of the pavement.—As has been stated, it is a substantial pavement. On the streets of heavy traffic the strain of ponderous Belgian wagons and immense Flemish horses must be considerable. Conversely, its character and universality, for there is scarcely an unpaved street in any town, necessitate strongly built carriages. Therefore an American buggy would be unsuitable here.

There is a peculiar danger to the towns in the event of riots, as has been illustrated in the past. The paving stones, when once one is removed, are easily detached and make convenient and formidable missiles in the hands of a mob for the destruction of life and property.

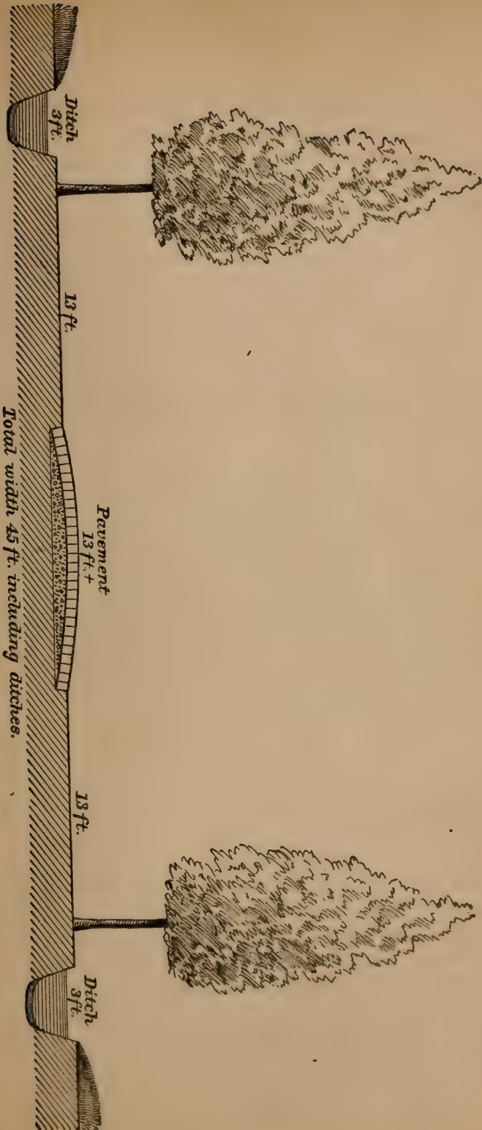
II. COUNTRY ROADWAYS.

The number of roads in the country has been nearly doubled since 1830. There are four kinds to be considered, those made respectively by the central government, the provincial government, communal authority, and by private individuals. The roads all have the center paved in the style of the streets. Except on the great highways, the width of this paved portion rarely permits the passage of two teams upon it. The following are the average dimensions of the great government roads traversing the city of Ghent:

Road.	Total width.	Width of paving.
	Ft. In.	Ft.
Antwerp to Lille via Ghent (France)	42 8	15
Brussels to Ostend via Ghent	44	16
Ghent to Valenciennes (France)	40	13

The provincial roads connect less important places and have inferior dimensions. The communal roads or *chemins vicinaux* comprise all the small country roads. The last class, those made by individual enterprise, or *Routes concédées*, are constructed with the permission of the government entirely at the expense of the individuals, who also engage to keep the road in repairs for a certain period, usually 99 years. In return they are allowed to charge toll for this period. At its expiration the road becomes the absolute property of the Government.

Method of construction.—The manner of paving the central portion is the same as that employed for the streets. The earth taken out is thrown on either side upon the unpaved strips.


Ditch
3 ft.
13 ft.
Pavement
13 ft. +
13 ft.
Ditch
3 ft.
Total width 45 ft. including ditches.

In the case of the large roads ditches are made on both sides beyond the unpaved portions. A sectional view of a government road is appended.

Cost of building and repairing.—The cost of paving varies from $1.10 to $1.21 per square yard, the blocks and sand being included and size No. 4 being used. The cost of making the unpaved portions is comparatively slight, the earth used being at hand.

The cost of repairs in the pave varies from 5 to 8 cents per square yard, according to their nature.

The wages of road laborers are 6 and 7 cents per hour.

Maintenance.—The roads are kept in as good condition as can be expected. The unpaved portions easily become muddy, owing to frequent rains and the character of the soil. An extraordinary precaution is taken when it thaws, which is no less than a law regulating the weight of loads which may pass during the continuance of the thawing. At the moment that it sets in, the governor of the province issues a proclamation that "*les barrières sont fermées*," this being an old expression signifying that the road is closed, usually for an indefinite time. This is published in the newspapers and in public places. The law provides with exactness what are the maximum loads allowed under different conditions. For instance, a one-horse cart with narrow tire can not pass with a load of more than 880 pounds. But a broad-tired one may weigh 1,540 pounds, and a broad-tired wagon is allowed to pass with a ton. Exceptions are made in the case of the mail, coaches, carriages, and army wagons, but the last must be furnished with a permit from the governor showing the weight. Fines are established for a violation of these provisions which apply only to the roads in the country.

JOHN B. OSBORNE, *Consul.*

UNITED STATES CONSULATE,
Ghent, December, 16, 1890.

LIÈGE DISTRICT.

REPORT BY CONSUL DANFORTH.

PRELIMINARY REMARKS.

One can mount his wagon at the English Channel and drive through the breadth of Europe (except in time of snow) or its length, without sinking as deep as the fellies of his wheels in mud in any weather or at any time of the year. The roads are so firm that rain does not soften them; they are so thick that frost does not break them up. There are no sloughs to wade through, no periods when the factory and the farm are cut off from the rest of the world by an impassable sea of mud. Two horses start with a cart or wagon weighing a ton, having upon it a load weighing two or more tons, and arrive with no breakage and at least

friction to their destination. The loss in breakdowns of vehicles, of breakage in harness, in time to labor, in increased food, shortened life, and injuries to horses by our bad roads in the United States would amount to an immense sum of money if statistics could be gathered and formulated. Without doubt the economy from this one source would go far towards keeping a road in repair when once it was thoroughly constructed where traffic is considerable.

The economy of good country roads to those using food and fuel in our large but more especially our small cities is also to be emphasized. Railroads, also, are directly interested in good country roads. Whatever opens up the remote farm lot for easy hauling to the railway station, or brings an additional acre of arable land nearer to the city, cheapens the market for the poorest and increases the volume of trade and commerce for all. The whole community shares in the benefit, and can therefore afford to share in the expense of building and keeping such roads.

PRESERVING THE LANDSCAPE.

The chief material for the construction of durable roads is rock of some kind; the harder the rock the better the economy, other things, such as accessibility, vicinage, etc., being equal. A hard-rock country usually possesses a beautiful or a sublime landscape. Nature has taken thousands of years to construct that land scape. From the beautiful valley of the Ourth, not far from Liège, immense supplies of stone are taken for city streets and country roads. Yet the great picturesque ledges of rock repose untouched in the same sublime forms into which the ages and the storms have fashioned them. Stone quarries have been opened from ridges behind the river fronts of the hill ranges, and by cars attached to wire ropes the stone is passed down to the river and directly into the boats and carts at less expense than it would have taken to work quarries near the river bank. Gravity does most of the work. The full car from the high hill lets itself down and pulls the empty one up. It is to be hoped that improved roads will not result in damaged scenery. The two advantages of good roads and unmarred scenery are compatible where the spirit of taste is blended wth the spirit of utility. When it is remembered that unblemished scenery has its market value, commanding a higher price, men may be induced to veil their assaults upon the hills.

STREETS.

The extent to which squared hewn stone is employed for street and sidewalk and scarcely anything else, creates an appalling monotony of Belgian pavement in the cities of this consulate. The sidewalks reproduce, in miniature cubes of 4½ inches by 4½ inches, the appearance of the streets, which one could wish himself shod in iron to escape the discomfort and pain caused by the inequality of these torturing cubes. The stone slab and the asphaltum walk are luxuries belonging to other

parts of our planet. Nor is there such traffic in our city streets, either in weight or amount, that compels resort to those expensive foundations employed in the immense cities of London and Paris.

I give below the cost in construction and maintenance of this city of Liège possessing 165,000 inhabitants. It is in the midst of a densely populated industrial district and heavy loads of iron and coal are trucked upon the streets. This street traffic is much heavier than in most cities of a similar size in the United States. The square cubes of stone are laid upon beds of broken stone or ashes in the more prominent streets; in other streets upon the natural beds of the earth with a slight layer of sand as an absorbent, the curve being about 1 in 30. Curbstones measure 7½ inches in width, 3½ to 6 feet in length, 1 to 1½ feet in depth, and are tongued and grooved at the ends to about 1½ inches. The paving stones or blocks still used here have been rejected as too large for the best results where the heavier traffic of larger cities is more exacting. They wear round and knobby, become slippery, and are moved to inferior streets, whence they are finally removed to be broken into small stones for roadbeds and for park, boulevard, and country roads.

It is to be regretted that the natural twofold division of city streets and country roads suggested by the department can not be strictly followed in this report. The streets and roads of Belgium are peculiar. They interblend. We have city streets partly constructed of paved ways and partly of broken stone, while into the country extend the paved crowns of square blocks of stone with broken stone roadways upon each side. It may therefore be of interest, and not without profit, if the classification observed in Belgium by the Government is outlined, bearing in mind that some of the Belgian country roads resemble some of our city streets lacking curbstones.

The streets and roadways of Belgium are built and maintained by three different authorities—the state, the province, and the commune (the city or the village).

But the supervision, in the last resort, belongs to the state, that through its engineers and supervisors must approve of all that has been planned or accomplished in the construction and repairing of roads, or granting concessions for small rail or tram roads to use the common roads. No material can be used in building or maintaining roads unless the state approve of it. It is, however, generally admitted that the material, that is the nearest, has to be considered in the first place; but where there is no kind of material near the place the very best is to be procured. The material generally used is granite, grit, and limestone.

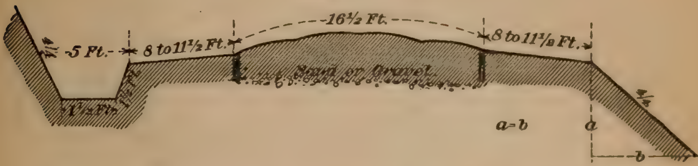
The building as well as the maintenance of roads is done in three ways: By sealed bids, in which case the lowest bid is considered if a responsible person. He has to build or maintain according to the plans previously published in conformity with detailed specifications.

(2) The streets or roads are built or repaired and maintained under the supervision of the state, the province, or the commune. This way is called by *régie*.

(3) Sometimes the two methods are combined.

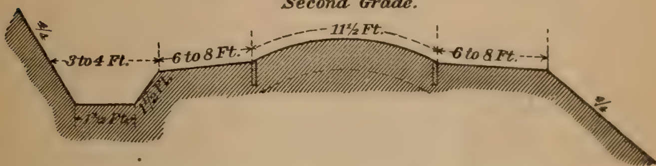
Highroads are of three grades:

First Grade.



First grade, width within the borders 16½ feet; sidewalks, 8 to 11½ feet; ditch, 5 feet; depth, 1½ feet to 1 foot 8 inches.

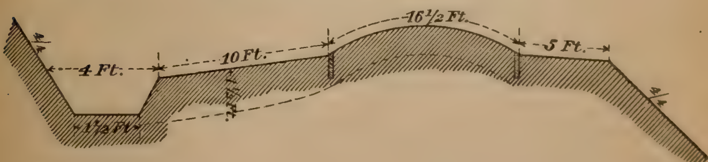
Second Grade.



Second grade, width within the borders, 11½ feet; sidewalks, 6 to 8 feet; ditch, 3 to 4 feet.

Third grade, width within the borders 10 feet or even less.

New road destined to receive a small railway or tram.



Where the highroad is designed to receive a small railway a sideway is constructed for the purpose, whose foundation is 1½ feet, with a width of 10 feet.

PAVED ROADS.

The paving stones 6 to 6⅝ inches in width and 6½ to 7 inches in depth. These 6½ to 7 inches with the foundation form the roadway, which is generally 12 inches.

The roadway is maintained by two sets of borders, having the same width as the paving stones and 11 to 14 inches in length; in height they fill generally the whole depth of about 12 inches. Under the pav-

ing stones is a layer of sand, gravel, or ashes from a zinc mill, of 8 inches; this is rammed to the prescribed curve of cross section, which is one-fortieth of the width of the road.

The cost of these roads varies according to the material and the distance they are from the place where they are to be employed.

The average cost of construction is $1.13 a square yard.

MACADAMIZED ROADS.

Depth of the roadway 12 inches, limited by two ranges of borders; the foundation consists of rough stones drawn closely together, vertically, of about 7 to 8 inches height; this stone bed is then covered with a 4 to 4½ inch layer of broken stones.

The curve of cross section is also one-fortieth of the width of the road.

The cost of building varies as in the case of paved roads. The average cost is 40 cents a square yard.

MAINTENANCE OF ROADS.

The paved roads are kept in repair by the use of new stones where needed; the rejected stones are given to the property owners bordering upon the main road if they wish to pave the sideroads, or are given to the commune to pave ways connected with the highroads. In the contract the quantity of old and new stones is mentioned, but all other repairs, to whatever they amount, have to be done at a fixed price by the contractor.

The average cost per yard is $0.01775.

However, in city streets, where only new stones are employed, the average cost of maintenance is about $0.041945 per square yard

MAINTENANCE OF ROADS OF BROKEN STONES.

The maintenance of this kind of roads consists in renewing the supply of broken stones to keep the curve of the cross section at one-fortieth of the width of the road. This is done by contract and the contractor has to fulfill his engagement, whatever may be the amount of work to be done.

The cost is about $0.0129 per yard.

Experience has shown that the value of the ground is in direct ratio to the good condition of the streets and roads by which they are traversed.

"Indeed it depends on the state of the roads and ways to improve the soil to put to profit the forests, mines, and industrial plants," are the words of the engineer of public roads and highways, with which I close this report.

JAMES R. DANFORTH,
Consul.

UNITED STATES CONSULATE,
Liège, February 24, 1891.

DENMARK.

REPORT BY CONSUL RYDER OF COPENHAGEN.

HIGHWAYS.

The construction and maintenance of the public roads in Denmark are under the management and at the charge of the local municipal boards, subject however to State supervisal, and these roads may be divided into four classes, according to the extent and nature of the traffic.

In the first class are placed such roads as have a daily passage of at least 100 vehicles, and which at the same time have a large traffic of heavily laden wagons. Such description of traffic in this country may now be confined to the limit of the nearest one-half Danish mile (1 Danish mile = $4\frac{2}{3}$ English) leading to the main entrance of the principal provincial towns. The chief characteristic of this class is a strongly built substructure capable of bearing the pressure of all heavy traffic (however light the wear and tear superstructure might be) with a good superstructure of broken stone of about 10 inches in thickness.

In the second class are reckoned such roads as are frequented daily by 50 to 100 vehicles, with some but no considerable heavy goods transport. Such description of traffic may be said to embrace all the more important public roads beyond the one-half mile limit leading from the towns. The main feature of this class is a good foundation with a wear and tear superstructure of screened rubble or of small broken stones of about 8 inches in depth.

To the third class belong all roads with slight carriage traffic, say from 20 to 50 vehicles daily, and without any goods conveyance. This class has a strongly constructed superstructure about 8 inches thick, composed either of screened gravel or of broken stones, with a substructure of unscreened rubble.

To the fourth class belong all roads with a daily passage of less than 20 vehicles. This class of roads has only a superstructure of 3 to 4 inches thick, composed either of screened or unscreened rubble.

In the substructure of these different classes of roads a greater excavated mass than of 10,000 cubic fathoms (about 66,700 cubic metres) per Danish mile for the first class seldom occurs. In the second class the excavated mass will seldom exceed 5,000 cubic fathoms per Danish mile; and for the third and fourth classes, such excavation as a rule will be under 15,000 cubic metres and not unfrequently even below 6,000 cubic metres per mile. The full breadth of the different classes of roads,

with the deductions for side paths, ditches, etc., and the breadth of the carriage road are as follows, viz:

Description.	Full breadth of highway.	Deductions for sides.	Carriage road.
	Feet.	*Feet.*	*Feet.*
For first-class road	32 to 40	16 to 20	16 to 20
For second-class road	28	14	14
For third-class road	24	12	12
For fourth-class road	20	10	10

The drains beneath the roadways are as near as possible of similar construction for the three first classes; in most cases with granite sidewalks and pavement, the whole being covered with a thick layer of clay. It is only an exception when the drains are of brickwork. In the later years glazed drain pipes have, however, been often used for drains of smaller dimensions. For the carriage ways, the dimensions of which have been given, in the first-class roads the substructure as a rule consists of irregularly broken stones 5 to 6 inches in diameter, packed closely by hand; or else of a layer of coarsely screened gravel containing stones up to 4 inches in diameter; which after the addition of a thin layer of small hand-broken stone of 1 to 2 inches in diameter is rolled until well bound together; whilst the wear and tear superstructure will generally consist of small granite road metal of about 1¼ inches in diameter. This layer is at times divided into two parts; namely, of a lower stone layer of 1¾ inches with an upper layer of stones of 1¼ inches in diameter; the whole being firmly bound together with an addition of sand gravel strewed over the path after one or two passages have been made by the rolling machine.

For the second-class roads will be used a similar wear and tear superstructure of hand-broken road metal or else of screened gravel, the choice depending in great measure on the difference in cost of the two materials at the spot where the work is carried on. Where the traffic is of lighter nature the screened gravel is found a very good material once the road has become well consolidated. The difference in price is matter of some importance, the cost of hand-broken stone varying from $8 to $21 per cubic fathom, whilst the screened gravel may be obtained for $2.68 to $8.

On the third-class roads, the wear and tear superstructure as a rule is simply laid on a foundation of 3 to 4-inch layer of coarse screened gravel, and as soon as this is somewhat consolidated by traffic or rolling a superstructure is laid, consisting either of hand-broken stones or of screened gravel 2 inches in thickness.

The cost of construction of new roads is very difficult to give with any certainty. It will depend not alone on the class of road, but also on the nature of the ground, as well as the difficulty in obtaining the materials, the extent of drain works, etc.; but, speaking generally, it is said that a first-class road, exclusive of expropriations, will cost from

80,000 to 100,000 kroners ($21,440 to $26,800) per Danish mile (4¾ English miles); the second-class roads from 50,000 to 80,000 kroners ($13,400 to $21,440), and the third-class from 30,000 to 50,000 kroners. The minimum cost of the fourth-class byroads, with fairly regular ground and good approaches, may be placed as low as 5,000 kroners ($1,340) per Danish mile, although this may more often approach to the sum of 10,000 kroners ($2,680).

The repairing of the roads.—Whenever the wear and tear superstructure, as on the first-class roads, is formed of a layer of hand-broken stones of 1 to 2 inches in diameter, the relaying is made as follows: Previous to the relaying, the still remaining part of the worn superstructure is scraped loose, after which the new material is laid down and leveled, and then firmly compressed with heavy rollers. It is then covered with sand gravel and again passed over some five or six times with the roller, until the road has obtained a thorough compactness. The relaying generally takes place in the autumn, in moist weather, and for the proper distribution of the work a systematic plan is prepared, and the repairs undertaken in a rotation of years on the different parts of the road, according to the extent of wear and tear variously shown. The annual supply of stone metal required for a fixed length of road will differ greatly. In the Copenhagen district, where the traffic is large, the annual consumption may amount to 123 cubic metres per 100 fathoms of roadway, whilst in the neighborhood of the more important provincial towns it will be about 80 cubic metres, and at a greater distance from the towns the consumption will fall as low as 40 cubic metres every sixth or tenth year for every 100 fathoms of road.

The public roads in Denmark, as before said, are now managed by and at the expense of the local municipal boards, subject to state supervision, as follows:

1. The highways and larger public roads are managed by the county council boards, but no works of extension or limitation can be proceeded with without the previous sanction of the home secretary. These highways have also to be inspected every year by a state inspector, who shall notify to the boards any existing wants, and should necessity arise he may order such works to be made good at the expense of the defaulting board. Each county board has also its own inspector, with assistant inspectors and roadmen, the cost of new works and repairs being borne by the county contributory fund, raised upon the taxed valuation of the land in the districts concerned. With the highways are also connected such main streets of the provincial towns as are a continuation of the road leading into the town, and these are placed under the joint control of the county council and town council boards, the expenses being defrayed by county as well as town councils, each with the half part.

2. *The by-roads.*—These are managed by the parish boards of guardians and town councils, each in its own sphere. All extensions or limitations of the by-roads are made at the recommendation of the parish

boards and with the sanction of the high sheriff and county council, and when works of more extensive nature are called for the county council can contribute their pecuniary share, the work being then performed under the direction of their own inspector.

In order that the home secretary may at all times be kept acquainted with the financial position of all matters relating to the public roads, the county council boards have to forward to the home department a yearly account, drawn up in an approved formula, of all expenses incurred on the public roads in their district. The home secretary has also the deciding of all matters in dispute relating to the roads. For this purpose the surveyor-general appointed by the state has to give his opinion on all road questions, and furthermore has to inspect yearly a certain quota part of the public highways ($\frac{1}{3}$–$\frac{1}{4}$ in each district), and at the close of every fifth year to furnish the department with a general report over the kingdom's highways and main streets for the previous 5 years' period, with statistical and financial returns appertaining thereto.

Expenses on road works.—The cost of yearly maintenance of the highways and roads does not alone depend upon the traffic or number of personal staff employed; but also on the cost of materials in the different districts. The daily repairs are made by permanent road laborers; of which in the neighborhood of a town one is generally employed to every one-half or three-fourths of a Danish mile, which proportion will be changed as by degrees one withdraws more and more into the country, when it may conclude with one road laborer to 1 Danish mile; and the daily attendance on the road may be reduced to an attendance of three days in the week. The superintendence of this work is performed by assistant inspectors to every 5 to 20 Danish miles, according to the nature of the roads. The annual cost of maintenance varies very much; for example, in the Copenhagen district, where the traffic in the immediate neighborhood of the city is exceedingly heavy, the cost of repairs may be excessive, running up to 20,000 kroners ($5,360) per Danish mile, when on the other hand in the thinly populated country districts it may not exceed 500 kroners ($134) per Danish mile; and perhaps the average annual cost of maintenance of these highways for the kingdom at large may be fairly placed at 2,000 kroners ($536) per Danish mile.

It can scarcely be said that the public roads in the present time have any effect on the land values; such may be more justly due to the great connecting railways, which have unquestionably exercised a favorable influence, especially on the value of landed property contiguous to the railway stations. The highways are no longer the great medium of conveyance for passengers and the great internal goods movements. This work is now monopolized by the great railway network of the kingdom, the highways being now more or less reduced to the position of partial feeders to this newer dominating medium of internal intercourse.

STREETS OF COPENHAGEN.

It will be sufficient to confine my remarks to those of this capital. From the latest official returns at the close of the year 1886, the area comprising the public streets, boulevards, etc., of this city was at that date about 20,100,000 square feet distributed in the following manner, namely:

	Square feet.
Carriage-ways, gutters, etc.	12,000,000
Side foot-pavement	5,750,000
Planted avenues and boulevards	2,370,000
Total	20,120,000

The breadth of the streets varies greatly. In the older parts of the town very narrow streets are still to be found, whilst in the new quarters of the city the minimum regulations under the present building laws will be found to exist, namely, a breadth of 40 to 50 feet, and where the streets have a more important carriage traffic a breadth of 60 to 80 feet. The streets as a rule consist of one roadway with two side foot-pavements, and where no special conditions call for a deviation from these rules each side foot path will have a breadth of one-fifth of the entire street breadth. The roadway form is of the arch of a circle, the road on the paved ways having a fall of 1 in 30 to 1 in 40 and on the macadamized ways of 1 in 25 to 1 in 35.

The formation of the different classes of carriage-ways are as follows, viz:

THE PAVED ROADS.

Materials.—For the paving stones granite is exclusively used, of which the chief part comes from Sweden. The heads of these stones have a rectangular form with a length of 7 inches to 9 inches, breadth of 4 inches to 5 inches, and height of 7 inches to 8 inches. As between the head and root a divergence is allowed up to 1 inch in the length and breadth, and the cost of these stones per square fathom is $4.82 for first sort and $3.48 for second sort. For pavements requiring a special foundation a better class of stone is used, namely of the so-called class "English hewing." The dimensions of these are 3½ inches to 4½ inches in breadth, 6 inches to 12 inches in length, and 6½ inches to 7 inches in height. The severer conditions demanded for this class of stones have naturally an influence at the same time upon the cost, the price of this special class being from $5.90 to $6.70 per square fathom.

Carrying out of the works.—The pavement as a rule is laid upon a sand layer 7 to 8 inches in depth; the stones being placed thereon at right angles to the direction of the street; the whole being stamped down with heavy butts worked by 4 men.

All work for laying of new pavements, as well as all relayings of any importance, is always submitted to contract by public tender.

In individual cases of much frequented thoroughfares, it has been the practice of late years to give a good foundation underneath the upper paving. This foundation in some cases consists of 4-inch to 6-inch thick layers of Portland cement; but more frequently of a bottom layer of stone laid flat side down, the whole wedged together with smaller stones. Upon this a layer of broken stones is spread, in such manner that after a pressure with heavy iron rollers, this layer will remain with a thickness of 3 inches at the sides, and of 5 inches in the center; and on this firmly rolled foundation, the paving stones are placed upon a 1-inch thick layer of gravel.

THE MACADAMISED CARRIAGE WAYS.

Materials.—For the foundation layers of granite or flint are employed, and for layers of broken stone exclusively of granite; the broken stones to be clean, well-screened, and not over 1¾ inches large.

Carrying out of the works.—The foundation stones and layers are laid in exactly the same manner as the pavement ways in the greatly frequented thoroughfares. The keeping in repair of this class of roads is for the most part done by the corporation's own work people.

THE SIDE FOOTPATHS.

In all the main thoroughfares and principal streets; these are paved with small paving flags of about 4 inches square, costing $3.75 per square fathom; whilst in the less frequented parts of the city a considerable part of the footpaths are macadamized, having a 3 inch to 4 inch thick layer of small-sized broken stone, covered over with earth gravel; the whole being well consolidated under passage of heavy iron rollers. This footpath covering has, however, in the later years been more and more displaced by tar-beton pavements. This consists of an undermost layer of untarred small stones or broken brick; thereupon of a 1½ inches thick layer of ½ inch tarred stones; this again with a 1 inch thick layer of ¼ inch sized tarred stones, and over the whole of a layer of tarred gravel; each layer being separately rolled over with the heavy rollers. The cost of such tar pavements when laid down may be reckoned at 5 to 6 cents per cubic foot.

The expenses entailed upon this city in laying out of new streets and sewage works, as well as for keeping in repair of the street ways, as also of closed and open drain passages, etc., in the year 1888 (the latest printed returns) amounted altogether to 1,237,400 kroners ($331,623), which was distributed in the following manner, viz:

Class A, cost of repairs of street ways, footpaths, drains, etc., watering and cleaning streets, salaries and wages, etc., $161,953.

Class B, cost of new street ways and sewerage works, $169,670.

The amount under Class A, constituting the running expenses, is included with the other municipal outlays in the annual budget of the

city to be covered from the rates levied upon the inhabitants for these purposes, whilst the amount under Class B for the undertaking of new and extraordinary works is, on the other hand, met through the aid of loans contracted by the corporation for such outlays, which loans, with the high credit of the city, can be obtained at about par rate and at an interest of 3½ per cent. per annum.

HENRY B. RYDER,
Consul.

UNITED STATES CONSULATE,
Copenhagen, April 15, 1891.

FRANCE.

REPORT BY COMMERCIAL AGENT LOOMIS, OF ST. ETIENNE.

A CENTURY OF SUCCESSFUL ROAD BUILDING.

The modern road system of France was inaugurated by the First Napoleon and carried forward to its satisfactory and splendid conclusion by the late Emperor, Napoleon the Third.

The roads of France are now practically all built, and they are substantial monuments to the Napoleonic foresight and shrewdness. The work of the engineers in the department of public works in France to-day is not to build new roads, except in rare instances, but to keep those already constructed in a state of high efficiency. There have been no important new roads opened in France for a dozen years, and the country is so traversed with excellent roadways that no more lines of communication are likely to be exploited save in the case of military necessity. The wagon roads of France, always passable and reaching all centers of population, no matter how small, are the chief competitors of the railways, as means of communication by water are not numerous.

VALUE OF FRENCH ROADS.

The road system of France has been of far greater value to the country as a means of raising the value of lands and of putting the small peasant proprietors in easy communication with their markets, than have the railways. It is the opinion of well-informed Frenchmen who have made a practical study of economic problems, that the superb roads of France have been one of the most steady and potent contributions to the material development and marvelous financial elasticity of the country. The far-reaching and splendidly maintained road system has distinctly favored the success of the small landed proprietors, and in their prosperity, and the ensuing distribution of wealth, lies the key to the secret of the wonderful financial vitality and solid prosperity of the French nation.

TYPICAL ROADS.

The French roads have compelled the respect and admiration of foreigners for a century, and of all the roads in the country those considered the most excellent, and at the same time most difficult of maintenance, happen to lie in this consular district, which contains in the Isere some of the most rugged of the French Alps, with their peaks forever snow clad and rising to a height of 11,000 feet.

Another department, that of the Loire, is a great industrial center, and its roads are subjected to the wear and weight of vehicles heavily laden with iron, coal, castings, and blocks of stone. It is also a partially mountainous region.

The French road engineers consider the roads in these two departments, the Loire and the Isère, as examples of the highest type of perfection to which modern road-making has reached in this country.

The roads in these departments are numerous, of easy grade, solidly built, always open and always good, save when temporarily blocked with snow. They are subjected to the most changeful and violent forces of nature. Snow, frost, ice, and furious glacial torrents springing suddenly into existence at unexpected points have sought for a decade to destroy them, but in vain.

In the high, mountainous regions of the Isère I have seen, after violent summer rain of 36 hours' duration, 50 yards of national road, including a small bridge, washed away by a fearful torrent rushing down from a cloud-capped field of ice, with an almost vertical fall of 2,000 feet. In 3 hours, and in the midst of a severe storm, I have seen that same road repaired temporarily and made passable by the road men in this remote and little frequented region.

It is this never-failing watchfulness and promptness in repairing roads, coupled with thorough and honest construction, which gives France a system of roads which is at once a source of national strength and of national pride.

From the road records of the departments of the Loire and the Isère, from recent observations and from the practical communications of the working engineers, I have condensed some information covering the principal points in the methods now employed in building and preserving French roads.

DIVISIONS AND CLASSIFICATION IN FRANCE.

In France the ways of communication are divided into three classes, as follows: First, national or state roads constructed and maintained by the state; second, department roads entirely at the charge of the departments, and, third, township roads which, though constructed by the communes, receive in most cases support either from the state or from the departments for their maintenance.

The national roads radiating from Paris communicate with all the

important cities and the departments in the country. They are placed under the jurisdiction of the ponts et chaussées (department of bridges and roads), which is attached to the bureau of the minister of public works. The second and third class of roads form a network over the country and are under the supervision, in a general way, of the prefects and mayors. However, in most departments these roads, too, are also intrusted to the care of the ponts de chaussées.

Further, there exists in towns of a certain importance a municipal road service, the business of which is to construct and maintain streets and roads within the limits of the city.

LEGAL PRELIMINARIES.

For the construction of a road two principal operations are required, viz: First, the formation of the bed of the road as well as the construction of the water ways and bridges when necessary; second, the making of the road with paving stones or by the method of Macadam in order to render it fit for traffic. When the need for a new road felt in a given district, an estimate with designs is drawn up and forwarded to headquarters, together with evidence justifying the demand. When this formality has been gone through, civil engineers go over the region, examine the direction the road is to take, draw up an exact estimate of the cost, make the specifications, and write out in detail for the benefit of the contractors their observations on the manner in which the road should be constructed.

The report of the engineers is sent to the proper authorities.

Before commencing the work the authorities proceed to acquire the necessary lands through which the road is to run and the proprietors are invited to sell the rights of way.

If a landowner demands a much higher price than the estimafed value, the Government appoints a special jury to appraise the land and it is condemned on their valuation, from which there is no appeal. This act is called in France "*Acté d'expropriation*," or dispossession.

The work is then placed in the hands of the contractors, who must execute it under the supervision of the engineers and according to the stipulations of the estimate, and if any difference arises between the contractors and the engineers it is brought before the conseil de prefecture, from the decision of which body, however, an appeal can be made to the state council.

RUNNING THE LINE.

It is not necessary to go into the political, commercial, or industrial considerations which induce the Government or local administration to decide upon the creation of a road. It will be sufficient to imagine two given points which it is desired to unite by means of a new road and to mark out within these limits the best line, bearing in mind three

cardinal points, economy in the working expenses, security for the traffic, and the cost of repairs, which should be reduced to the lowest degree.

To trace a road a topographical chart is first studied in order to obtain the exact positions of the extreme points and their relation to the neighboring or intermediary points. The ground is then gone over in order to complete the information furnished by the chart and to discover other points if necessary which would be preferable in a technical or commercial point of view. These might be bridges, which could be used with advantage and thus realizing a certain saving, or in the case of a stream where the construction of a bridge presented more facilities than at the points originally indicated, or, again, certain depressions in the ground which would permit the road to pass over a hill with a lower gradient, or, lastly, where populous centers require that the proposed road should run through them.

A careful and well considered examination having been made on the main points of the line, sections of more or less length are studied so as to unite them all, finally, with more facility.

It is impossible to lay down a general and absolute rule, to obtain the best tracing between any two points. The nature of the ground and the intelligence and liability of the operator have a certain bearing on the end in view. However, a good method of avoiding grave errors and much trouble would be, trace at first upon the plan of the region between the two points a straight line uniting them; this line forms the tracing of a vertical plan in which the axis of the projected road is placed.

The next thing is to consider, first, if it would be possible to make on this plan either a uniform incline or a series of inclines, not exceeding the degree of inclination previously fixed and at an average cost; second, if this plan did not encounter material obstacles, such as swamps, mountains, or buildings, which could not be overcome without considerable expense; third, if by going to the right or left of the line it would not be possible to obtain a more gentle incline or a decrease in the expenses of the construction or both together.

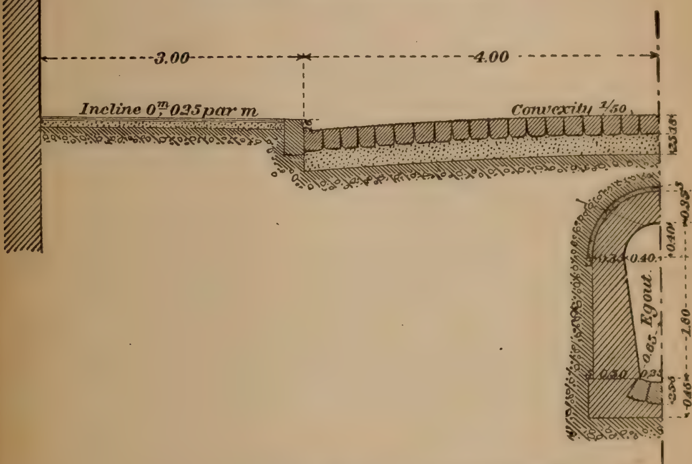
It is only in very rare and exceptional cases that a road can be advantageously traced in a direct line between the two points, even when they would be separated by a short distance. It is generally necessary to deviate in order to avoid difficulties to give the road the best position to escape heavy fillings or cuts.

EARLY DETAILS.

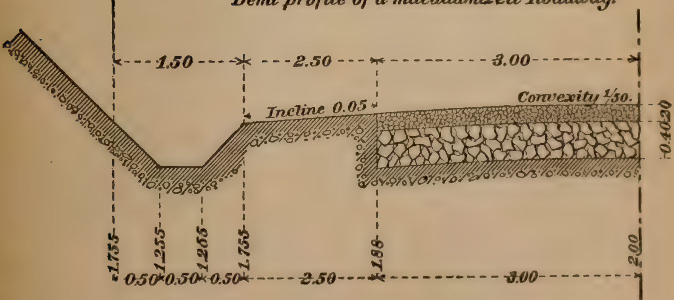
It is especially to mountainous districts that the foregoing considerations apply in deciding on the tracing of the road. The difficulties to be met with in those regions can hardly be explained in this report. It will suffice to say that the intelligence of the engineer reduces those difficulties as much as possible. The lowest points of the ridges are chosen and when possible the lines of the valleys are followed.

In general where the points intended to be united by a road are situated upon flat ground, the natural indication is the straight line, but more frequently the ground is intersected by marshes, streams, or buildings, and in that case the tracing must be modified to suit economical considerations, convenience, and solidity.

Demi profile of a paved Roadway.



Demi profile of a macadamized Roadway.



Scale 1/50 of a metre.

Where the ground is not very uneven the tracing can be made without much difficulty, but it would be well here to remark that a curved tracing lengthens but slightly a road and should be preferred to a zigzag line.

THE ENGINEERS' WORK.

When the termini are separated by sinuosities the grades of which are greater than those previously fixed, by valleys, ridges, or mountains, the direction of the tracing is difficult to determine. A simple bird's-eye view is not sufficient; the difficulties increase with the degree of the roughness of the country. If the road has to cross a chain of mountains, the lowest point must be determined at the outset in order to diminish as much as possible the expenses of the cuttings. To effect this object the following points will be found useful as hints in order to avoid long and tedious leveling:

PRACTICAL HINTS.

1. The ridge of a chain of mountains, without having anything geometrical about it, either in the horizontal or vertical sense, is, however, looking at it in the *ensemble*, nearly straight. It inclines always in the same sense as the valleys.
2. When a ridge meets at the same point two or more secondary ridges this point should be raised to the maximum level.
3. When a ridge meets two thalwegs (or valleys) situated on either side, the point of meeting should be a relative minimum.
4. When a ridge is met by a secondary ridge and a thalweg, it presents a horizontal inflexion at the point of encounter without presenting anything particular in the vertical sense.
5. When two thalwegs after having been parallel diverge in opposite directions, the point where they meet the ridge is necessarily a minimum.
6. When two thalwegs observe paralleled courses for a certain extent, but running in opposite directions, the ridge ought to present a minimum point in the interval which separates the two thalwegs. If the points chosen are situated in the same valley, the water courses must be taken into consideration.

The question of choosing the site of bridges is very important; so important, that if the river to be crossed is considerable the direction of the road must be rendered subordinate to the site of the bridges. If there exist several practicable points of passage, they must be compared carefully in order to select the one most suitable and conforming to the following conditions: Good nature of the ground for a firm foundation, normal direction of the current, stability of the bed of the river, and concentration of the waters in the same bed. If one terminus be situated in a valley and the other on the slope of a hill, the solution will depend in a great part on the average slope of the ground between the terminal points. If this slope conforms in general to that already fixed the tracing is made in a straight line.

THE OLD WAY.

In short, if the average incline is inferior to the limit fixed several solutions are possible.

The straight line might be taken, but this tracing is not much observed to day, for it happens more frequently that the points to be joined are separated by secondary valleys which would have to be crossed with a great deal of difficulty and inconvenience. Many of the old roads were constructed on this system. They were projected over mountains and valleys regardless of the natural obstacles of the route or the interest of the population, and as they were pushed on boldly, they were constructed at the expense of enormous trouble and never were they satisfactory. The aim supposed to be in view, the shortening of the distance, was far from being attained, as the delays arising from the up and down hill nature of the road lengthened in reality the distance much more than the curves of a level road.

Another system consists in following in a horizontal line as much as possible the ridge in its length, and descending to the second point by a gradual incline. This method was much employed formerly, and had the advantage of crossing the streams almost at their source, necessitating consequently but comparatively unimportant outlays for the crossing. But ridges which are generally sinuous require a very undulating tracing, and being but sparsely inhabited, the road loses much of its importance.

A third solution, and the one generally employed to-day, consists in following the valleys as much as possible, and rising afterwards by gentle grades. This tracing traverses the cultivated lands, regions studded with farm-houses and factories. The value of such a line of communication is much more considerable than that of a route by the ridges. The water courses which flow down to the principal thalwegs are, it is true, crossed where they are largest, and require works of large dimensions, but also they are fewer in number.

MOUNTAIN ROADS.

The terminal points may be situated on the slopes rising from the same valley, and then the shortest route would be to go down directly from one side, cross over, and ascend the other. This direction, however, is often impossible on account of the inclines being too great on either side, and would necessitate the filling up of the valley, causing thus great trouble and expense. It is much preferable to run along the side of the hill, observing a gradient and to go up on the other side in a similar manner. The valley can be crossed then without requiring a heavy embankment. But of course the length of the road is thereby much increased as well the expense of the construction.

Whenever it is necessary to unite two given points situated in different valleys separated by several small ridges the difficulties are very

great, and increase with the importance of the uneven nature of the ground. The points of passage over the ridges are first determined, always bearing in mind the probable cost, which should be as low as possible. When they are fixed upon, the outline is subdivided into different lengths and examined apart. It can be easily inferred then that the chief difficulty lies in choosing these points of passage over the ridges. Moreover, before fixing on the points of passage, it is necessary to be assured that they can be reached, for sometimes this is impossible as the hillsides are too steep.

CONSTRUCTION OF THE ROAD.

When the outline of the road is fixed upon, the profile of the length is exactly marked out as well as that of the breadth, so as to evaluate the earthworks and the works of art. The transverse profile of a road affects generally the following form:

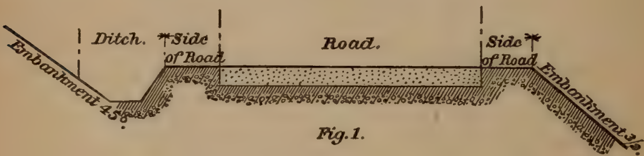


Fig. 1.

It is composed of, first, a roadway varying according to the importance of the road from 3 to 6½ yards in width, and even more in some cases, where the circulation requires it; second, the sides are also of variable width, and the ditch destined to receive the water coming from springs or rain. Sometimes a part of the sides is higher than the roadway (Fig. 2), and in that case it takes the name of footpath, and is

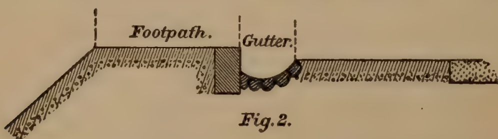


Fig. 2.

generally seen in towns, or in their neighborhood, to facilitate the circulation of the foot passengers. But in such instances it is necessary to establish a gutter to receive the waters of the street. The roadway is barrel-shaped, and the sides are sloped transversely in the proportion of one inch to the metre, to facilitate draining, the width of the ditches or gutters being in proportion to the amount of water to be received. The slopes or embankments are pitched at an angle of 45 degrees in the case of excavation. In mountainous regions a rectilinear profile is given to the road, which is inclined towards the side of the mountain especially in the curves, the convexity being on the side of the valley.

A wall confines the road on the side of the precipice, and a ditch runs along by the hill. In the case of large cuttings, the sides of the road are sometimes suppressed in order to diminish the cube of excavation.

It is not, however, always possible to construct a road on the above plan, for it often happens that the sloping of the ground is such that it would require a very large and steep embankment to cross the ravines.

In such cases the embankment is replaced by sustaining walls on either side, as shown in Fig. 3.

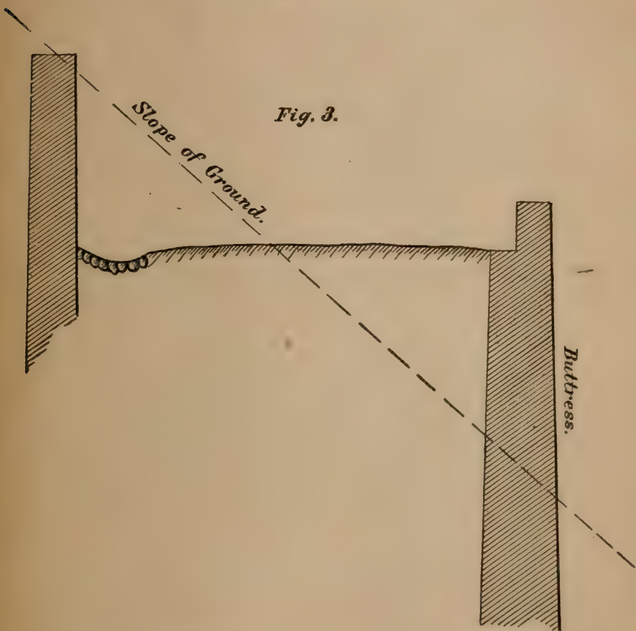


Fig. 3.

The foundation must be well laid, and the thickness sufficient to resist the weight of the soil. These walls are built wherever they cost less than the embanking process, and when the security of the traffic requires it.

The construction of a road brings often to light springs which appear at first sight harmless, but little by little they saturate the soil and end by washing it away. In such cases drainage must be rigorously applied so as to prevent inevitable consequences.

MODE OF CONSTRUCTION.

The greater part of the roads in France are macadamized; it is only in towns that paving stones are used. The layer of broken stones com-

posing the road is from 12 to 25 centimetres thick. This layer is placed directly on the beaten ground. In exceptional cases a layer of sand intervenes, or even stones of a certain magnitude, in order to facilitate the drainage. Sometimes the stones are undressed cobbles, such as are found in the beds of rivers or on the seashore, but this kind of pavement is seldom used now. The paving most generally used is made of hard granite, and laid at right angles to the axis of the road. The cuniform paving stones vary from 10 to 20 centimetres in depth; much larger ones are sometimes employed in the principal streets, however.

A good pavement should meet the following conditions: First, it must furnish a good foothold for horses drawing heavy loads; second, the stones should be so placed that the wheels shall not run between the interstices for any distance; third, one part of the pavement should not be more resisting than another.

The construction of a pavement consists at first in hollowing out the bed for the stones and in placing a layer of sand of from 15 to 25 centimetres in thickness. The stones are then placed side by side, and the interstices filled up with sand. The operation is completed by an instrument called a *demoiselle*, which drives home the pavement and makes it regular. This *demoiselle* is a heavy rammer made of wood, and bound at the bottom, which is the larger end, with a strong iron hoop, and on each side a handle.

REPAIRS AND ALTERATIONS.

When a road is finished and opened to traffic it is not left to itself, for otherwise it would soon deteriorate and become bad. To keep it in proper repair two operations are necessary, that of removing the waste, such as mud and dust, and that of supplying new material to replace the loss by wear and weather. To the removal of mud and dust the French give great attention.

When a road is run over freely by vehicles for several days and the weather is dry a slight layer of dust is formed. This dust annoys the passengers and the horses and renders the road heavy for traffic. If rain falls the dust is converted into mud, producing ruts and faults of every sort, consequently the dust must be removed, and the instrument used is the broom. A well-swept road leaves no mud after rain, at least not for several days. However, if the humidity continues the road becomes at first sticky and finally is covered with mud, which should be promptly removed, as the mud makes the tracks of the wheels apparent, and as those tracks constitute a smoother surface for running on than the rest of the route other vehicles follow in them, and after awhile regular ruts are formed, which injure greatly the road. All the while, moreover, the wear and tear continues, although slowly, and consequently at certain periods the road must be repaired. As a rule wet weather is chosen for this operation, and the principle which ought to guide the roadman in his work is the avoiding of creating a special

track in the road for traffic. The vehicles should run over any part of the surface to prevent the depressions alluded to.

THE USE OF ROLLERS.

Formerly a road was opened to traffic immediately after construction while the stones were yet loose, but the inconvenience of this method has disappeared since use has been made of heavy rollers, which compress the material. A roller, or compresser as it is called here, consists of one or two heavy cylinders drawn by horses or propelled by steam. The cylinders weigh 4 tons, but this weight is subsequently increased by filling the large box over the cylinders with large stones. The rolling machine is first passed over the road with only its own weight, that is to say empty, and gradually stones are added. In order to effect properly the operation the road is previously well watered. Constant repairing is required, especially after heavy rains, but the material being always at hand, the work is promptly executed by the roadman.

BASALT VERSUS GRANITE.

Since 1846 the French engineers have generally used basalt instead of crushed granite on the roadways which are built for heavy traffic. This basaltic rock is found in great quantities in the adjoining department of the Haute-Loire. The basalt costs $2.50 per cubic metre, and 300 cubic metres are used for each kilometre, or sixth-tenths of a mile. It is not only far better, but about 30 per cent. cheaper, than the crushed granite, formerly so much used.

The cost of constructing a paved roadway is $2.35 per square metre and the cost of keeping it in repair is 8 cents per square metre per annum, while that of a macadamized road is from 5 to 10 cents.

THE ROAD SERVICE.

The road and bridge service of France is a strong and effective organization. Responsible men are employed in it, thoroughly trained, and their work is subjected to close inspection by government engineers. No part of the road system is neglected; the routes are divided into sections of half a mile to 3 miles in length, according to the importance of the road, each of which is confided to a man or number of men, so that every foot of the roadway is inspected daily and is kept in thorough repair.

Cost of good roads in France.

Average cost of building a road per kilometre	$6,600.00
Cost of a road in the valleys per kilometre	4,000.00
a road in a mountainous region per kilometre	9,000.00
keeping in repair per kilometre and per annum	440.00
embanking per cubic metre	.18
paving streets per square metre	2.43

Cost of a road in the valleys per kilometre—Continued.

paving stones (per 1,000 stones)	$48.26
ordinary workman per day	.58
man and horse hire per day	1.55
foreman per month	20.00
supervisor of roads per annum	600.00
engineer of roads per annum	1,000.00
head engineer	2,000.00

BRIDGES.

One striking and satisfactory feature of the French road system is that furnished by the substantial and often beautiful bridges which are seen in every place where the slightest need for them exists. These bridges are generally of stone, except in some cases where large streams are to be crossed, and then the suspension system is most frequently employed with satisfactory results. However in the case of road bridges where the span exceeds a certain limit iron is supplanting stone considerably in their construction.

The French bridges, like most of the streams which they cross, "go on forever," and I have thought it well to submit some information concerning their cost. The subjoined estimates refer to small bridges only less than a hundred feet in length.

Cost of bridges of various sizes.

Nature of work.	Span.	Length.	Cost.
	Metres.	*Metres.*	
Aqueduct, roofed with flags	.60	12	$117.00
Aqueduct, roofed with cut stone	.60	13	270.00
Small bridge, arched	1	18	618.00
Do	2	15	618.00
Bridge, arched	3	10	600.00
Do	4	11	1,000.00
Do	5	10	1,200.00
Do	6	12	1,650.00
Do	10	14	5,800.00
Do	20	6	4,900.00

The foregoing figures were extracted from the official record, and show the cost of bridges of a given class now actually in use.

FRANCIS B. LOOMIS,
Commercial Agent.

ST. ETIENNE, FRANCE, *April* 23, 1891.

FRANCE.

REPORT BY CONSUL KNOWLES, OF BORDEAUX.

ROADS AND ROAD MAKING IN FRANCE.

No greater builders of roads have left their mark upon the annals of time; none have regarded them of more vital import for the maintenance and strengthening of an empire; no more forcible examples of topographical engineering have been so indelibly presented to modern generations as the great highways of the Romans.

The finest roadways existing to-day in France, the greater arteries of inland traffic, were built by the same hands that constructed the Appian Way.

If, as some philosopher has wisely observed, roads form in the material advancement of a nation a cardinal element, being in no unimportant degree essential to its development and natural resources, then we may attribute to these mighty thoroughfares of France greater distinction than has ever yet been given them.

But France, like Carthage, has suffered by her greatness.

When the Prussian forces crossed the frontier in 1870, the fine military roads (*les routes nationales*) were found more advantageous to the invaders than the invaded. The enemy profited by the master work of their aggressive neighbors. The roads afforded not only direct, but excellent routes to the French capital.

The highways of France are remarkable for their durability, evenness, and cleanliness. They are swept and watered every day, and kept in scrupulous order. No rugged eminences or depressions jar the nerves of the traveler riding over them. Neither dirt, decay, nor rubbish is about to suggest neglect or ill care. They are immense garden paths, amid a marvellous landscape of verdure and cultivation.

The process of road making in France is very simple, and their excellence is without doubt due to the simplicity of construction as well as to the superior quality of the material used.

The method is briefly thus: The materials destined for the making of roads are brought from the nearest quarries and placed at either side of the route surveyed. In order that the full amount contracted for may be delivered, the stone must be heaped in angular piles of prismatic shape and fixed dimensions. These heaps, placed at a given distance from one another, are afterward inspected by an official inspector, and must in all instances fit exactly beneath a skeleton frame carried by him. The stone is usually marble, flint stone, or gravel. The material must be of the best quality and cleansed from all foreign substances.

The stone must be broken so that each piece may pass through a ring, 2½ inches in diameter. It is then spread evenly over the road;

the interstices being carefully filled in with smaller pieces and particles, so that the whole is smooth and free from abrupt eminences or depressions. A steam roller then crushes and further evens the whole, after which a superficial layer of clay and earth completes the work.

According to a mandate issued by the prefect of the department of the Gironde, France, the 29th of December, 1871, and approved by the minister of the interior on the 1st of January, 1872, the following resolution as to the maintenance of country and crossroads was taken.

The cost of maintaining and keeping in order of roads shall be borne by the inhabitants living in the section or district through which said country and crossroads are laid. Each taxpayer is obliged to work 3 days each year for the maintenance of the road, or has the option to pay an amount of money sufficient for or equivalent to the compensation of a laborer for a period of 3 days.

To insure faithful fulfillment of such services there is prepared in the bureau of the comptroller of taxes a schedule of taxpayers who fall under the obligations of 3 days' labor. The schedule is submitted to the director of "Direct Contributions," who, in turn, notifies each person of the 3 days he is obliged to work. The schedule sets forth, 1st: The number of members and servants in the family, the number of beasts of burden, and those used under the saddle or harness, the same being taken as a basis fortheamount of assessment. Each taxpayer is notified by the director of assessors of the number of days he is obliged to serve, or of its equivalent in money. The schedules are further posted in public places for the inspection of taxpayers, who may address any objections or complaints directly to the prefect.

The value of a single day's work is estimated as follows: Man, 2 francs; horse, 2 francs; ass, 75 centimes; cart, 1 franc; ox, 2 francs.

The services of those taxpayers who desire to fulfill their obligations in actual labor must be rendered between the first day of February and the first day of July, or between the first day of August and the thirtieth day of November. The length of labor is fixed at ten hours a day per man, and eight hours a day for beasts of burden. The taxpayer, five days before his services are required, receives orders, signed by the mayor, to present himself on such a day, at a certain place, provided with certain implements and prepared to perform certain work. If a taxpayer be prevented by illness from attending to these duties he can send a substitute to replace him, being at the same time responsible for his work.

In regard to reparations of roadways in France, the chief road inspector every year must furnish to the prefect of the department a list of the materials necessary for the making and reparation of the various highways and crossroads in the districts. The prefect gives the same to the contractor, who can not extract any materials from or open quarries except such as are officially indicated to him.

Every man who receives or makes a contract for road building or repairing must give good security, furnish certificates of capacity, and live close to the work in question. Of the moneys appropriated for the various contracts, 1 per cent. is retained by the prefect as a fund for the relief of the widows and orphans of any who may have been fatally injured in working upon the roadways.

The material used in the making and repairing of roads in France is usually the flintstone, marble, or ophite, quarried in Brittany or from the Pyrenees Mountains. The cost of this material can scarcely be estimated. In regions contiguous to the quarries roadmaking is naturally cheap. The greater the transportation, the higher the price of material carried and delivered at the proper place.

The following formula may be employed in determining the price of material:

$$X=\frac{P\,(2D+d)}{L\times C}+T$$

X represents the price to be determined; P, the price of cartage and labor; D, the distance of transportation; d, loading and unloading; L, traject of cart in continual motion; C, cubic measurement of the land; and T, the corresponding price of labor in loading and unloading.

The streets in the larger cities of France are, as a rule, paved with the ordinary cobble stones, resting on a 6-inch deep bed of sand and earth. The stones are quarried principally in Belgium, and vary in size from 5 by 3½ inches in length and breadth and 4½ in depth to 7½ by 4½ in length and breadth and 6 in depth.

The maintaining of the city streets and of the routes nationales of France is distinctly different than the maintenance of the roads, such as I have just described. The routes nationales, the principal roadways between the more important cities, are repaired and kept in order by the state; the expense of the same being defrayed, not by special taxation, but from the general funds. The same applies to local municipal governments regarding city streets.

I find difficulty in obtaining definite information regarding the proportionate increase in land values after the cutting through of new roads in France. That there is an increase is beyond all doubt. Exactly what it is, however, I can not determine.

Comparatively few new roads are made in the vicinity of Bordeaux, and many of the older ones date from before the Christian era. The routes of inland communication are already quite sufficient, and as the population of the French Republic is on the decrease, geographical contour remains almost unchanged.

HORACE G. KNOWLES,
Consul.

U. S. CONSULATE, *Bordeaux, January* 29, 1891.

ARRONDISSEMENT OF HAVRE.

REPORT BY CONSUL WILLIAMS.

INTRODUCTORY.

I have the honor to state that my reply to the State Department circular of November 8, 1890, entitled "Street and roadway circular," has been purposely delayed in order that I might make full personal inspection, thus making my reply as valuable as possible to whom it may concern.

In passing, and perhaps to emphasize the attention paid by me to the circular mentioned, it may be here stated that for years I have been connected with the movement in the State of New York and with its legislature to secure State action regarding the improvement of country highways in that Commonwealth as well as to an extent with like efforts in the city of Rochester.

In order to reply properly I have inspected road construction and repair in Havre and other cities of my consular district, and have journeyed into the country in company with Engineer M. Vacossin, who is trustee in charge of 435 miles of public roads of various makes and classes in the arrondissement of Havre, and thus inspected in several localities and under a variety of conditions both repair and road making.

I prepared a list of forty questions to which Engineer Vacossin made written answer, the manuscript and translation inclosed herewith; parenthetically I have added notes to the translation and reductions of metric units for the reader's benefit. Certain conclusions from my inspection here, and as modified by my experience, are subjoined.

FRENCH VS. AMERICAN ROADS.

New roads here are, if of block stone, made substantially the same as in the American cities and as outlined in my inclosures; if of broken stone, are made by first grading and draining, then spreading on a 7-inch coating of broken stone, rolling with heavy rollers, and, finally, sprinkling thickly a binding of sand, clay, or soil, which, rolled down and somewhat rolled in, forms the bearing surface; but such a coating would neither withstand the sharp pressure of loaded wagons having narrow tires nor the upheaval of the usual frosts of the Northern American winter.

The American pavements are very much better constructed than are those of France, all classes being considered. They, however, become destroyed in a short time, while those of France increase in excellence with age, until the difference is very marked. These differences arise from neglect with our authorities to promptly and properly repair and from the constant damage inflicted by the narrow tires of freighting vehicles.

In France all roads have perpetual attention. If, from weight of load, from rain, or other cause, a hollow, rut, or sink is formed, it at once receives attention, its surface usually roughened by picking, so that new material will adhere, and then the depression filled slightly, rounding with broken stone or stone chips. If the space repaired be of limited area, the rolling of the new coating is left to the wide tires of the heavy carts, but, with extended areas, a steam-roller is brought for use.

If a broad economy should be followed with the objective to make the highways of the United States like those of France, the first labor should be given to establish easy grades by cutting hills and filling valleys. This once done is forever done, and no road should be made until a grade not greater than 1 in 20 should be made, for to change the grade of an improved road makes waste of all the expense before incurred in its making. Thus grading is economy's first law, and is here the engineer's primary act.

The next step is to reduce the water evil to a minimum by either center blind ditch or side open ditches, or both, both especially in low sections and in springy soils, with capacious bridges and culverts of most durable material.

Then, having proper grade on a line free from water, less material and that of a less expensive kind can be properly used, and gravel rolled by wagon tires regulated as to width will do much to make a road.

Every freighting and market cart here is a road-maker. Its tire is from 3 to 10 inches in width, usually from 4 to 6, and so rolls the road.

With the few four-wheeled freight vehicles used the tires are rarely less than 6 inches, and the rear axle is about 14 inches longer than the fore, so that the rear or hind wheels run in a line about an inch outside of the line rolled by the fore-wheels; thus with a 6-inch tire 2 feet of road width is well rolled by every passing wagon.

The varied gauge is also usually observed with cabs, hacks, and other four-wheeled vehicles, so that they become road-makers instead of rut-makers, as in our country.

The narrow-tired wagon rides more smoothly over a bad road because its narrower pressure levels obstacles rather than surmounts them, while the wide tire, having less proportional leveling force, surmounts and creates the jolt; but just in the proportion that obstacles become leveled and road smoothed, as by the roller service of wide tires, the jolt disappears, and with such wheels on even an uncoated country road its bed, if kept rounded, soon becomes a watershed not likely to be materially softened by surface waters, while if to the surface a coating of gravel or stone chips be added and rolled the water is excluded, so that damage by winter's frosts becomes minimized and on firm soils even neutralized.

The cost of prepared material and of all labor, both for making and maintaining a road, in the United States is considerably more than double the like cost in France, but labor here is less active and efficient.

Then a road made as a pavement of broken stone, to withstand the frosts prevalent in all the United States north of about the latitude of Baltimore, must be at least twice the depth and constructed with twice the quantity of material as here, with proportionate outlay for labor; hence, allowing three elements of increase of cost in our Northern States above cost in France, of, first, double cost of labor; second, double cost of material delivered ready for use, and third, double depth or strength of road in order to resist frost and to resist the almost wedge-like tires of American wagons, and you have a fairly accurate estimate that a road after the French fashion, and made in our country so as to serve as durably there as roads serve here, will cost 2 by 2 by 2, or 8 times the cost here.

I am aware that such a report has little in it to encourage our making of good roads, but Europe has been centuries making hers, and in France frosts are trifling when contrasted with those which heave and destroy our roads every winter and spring; and the excellence of Europe's roads, as I learn, ranks in a graded scale from the frost latitudes southwards, those of Britain, Sweden, and Russia bearing no favorable comparison with those further south.

Then again the dense and old settlement of Europe, whereby farm ponds are so located as to catch surface water, ditches made and gutters paved to prevent damage by floods, and every spring confined and utilized, vastly tends to prevent the destruction of roads, for in the main water is the sole destroyer of American highways, and the owners of abutting lands instead of confining all water for farm and other uses, turn it, if possible, into the highway, where it flows unrestrained and by permeation softens every roadway, and often by its violence undermines and sweeps away portions of the roadbed.

Inclosures A and B are questions propounded by me and answered by Engineer Vacossin, of this arrondissement, while inclosures C D and E are digests of my own observations on roads and roadways.

OSCAR F. WILLIAMS,
Consul.

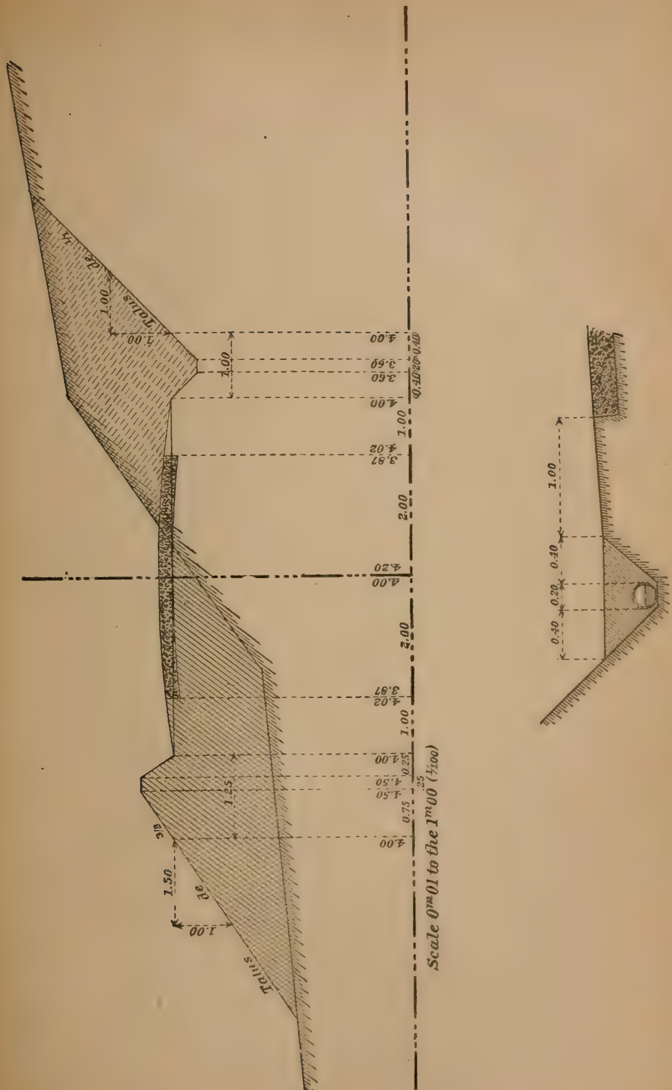
UNITED STATES CONSULATE,
Havre, *May* 29, 1891.

ROAD MAKING IN THE ARRONDISSEMENT OF HAVRE.

[Five inclosures in Consul Williams' report, A, B, C, D, and E, viz: A, general questions and answers as to roads; B, preparation of road before placing thereon any paving materials; C, considerations in road making; D, considerations in road keeping; E, general considerations of roads.]

A.—GENERAL QUESTIONS AND ANSWERS.

(1) Do the frosts of winter heave up and destroy your roads?—Answer. Rarely; however, every winter the frost does some damage on roads to a depth of about 15 centimetres (5.9 inches), especially in the parts where the subsoil is of a clayey nature.



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(2) What are the legal requirements, if any, as to width of tires?—Answer. Since 1853 such regulation has been set aside.

(3) Does the weight of cart, truck, or load change the requirement as to width of tire?—Answer. Such regulations were set aside in 1853.

(4) Is there a tax upon narrow tires or a bounty given for use of wide ones?—Answer. No tax; no bounty.

(5) Are all people and occupations permitted use of all roads for loads of every weight at all times and without tax? If not, indicate exceptions, restrictions, and tax.—Answer. Restrictions can be made to regulate the use of roads having great declivity or imperfect lines; for extraordinary damage a fine or tax is collected which goes toward the expense of repair. (Art. 14th, law of 21st May, 1886.)

(6) Are owners of abutting lands taxed for road building and repairs?—Answer. No.

(9) Are country roads swept of dust and mud or is the dust removed by winds and rains?—Answer. The road men are obliged to take away the dust and mud.

(10) At what distances apart are heaps of broken stone deposited for use in repairs?—Answer. The materials are laid according to necessity per lots, 1 cubit metre (1,308 cubic yards) alternately from right to left at a distance of 50 metres (9,942 rods), and outside of the lines of the road.

(11) Will you supply me a profile of a road?—Answer. A type profile of a road is hereto annexed. (An inclosure.)

(12) Supply me, if convenient, with brief general directions such as furnished to your under-directors as guides in making and repairing roads, as well as for the preparation of the materials therefor.—(Not answered except as within.)

(13) After a new road is completed is it ever again entirely made new, or is it perpetually maintained by repair of its surface?—Answer. The surface of the road is constantly kept in repair.

(14) For what average time in years have the principal roads of this portion of France been kept up by means of scientific state supervision?—Answer. Since 1836; application of the law of May 21, 1836.

B.—Preparation of line of road before placing thereon any paving materials, etc.

(A) Is it center-drained?—Answer. No.

(B) Is it drained other than by side ditches?—Answer. Yes, for departmental roads; the communal roads have no ditch.

(C) Is the center arched, and if so, to what height above the gutter?—Answer. No.

(D) What is the usual width between gutters?—Answer. Six metres (19.68 feet) for the departmental roads. The communal roads are of variable width, from 4 to 6 metres (13.12 to 19.68 feet) exclusive of ditches.

(E) What incline is allowable?—Answer. The profile in length presents no declivity above 5 centimetres per metre (equals 1 foot in 20 feet); the width profile having the form of an arc of a circle given a convexity of 13 centimetres at the axle, so 1 in 31 of the width.

(F) Is more than one sort of paving material used; how combined or placed?—Answer. Generally the paving stones used come from the quarries of May St. Valeny en Caux or Cherbourg; the paving stones are laid close to each other on a layer of sand 15 to 20 centimetres (5.904 to 7.872 inches) in thickness.

(G) What is the thickness of the paving coating, and how is it compressed and to what weight per square centimetre of contact with roller or compress?—Answer. The paving stones have generally the following dimensions, viz: Length 24 centimetres (9.45 inches), width 17 centimetres (6.69 inches), depth 18 centimetres (7.08 inches); or, length 20 centimetres (7.87 inches), width 13 centimetres (5.12 inches), depth 18 centimetres (7.08 inches). The pavement is leveled with a beetle, the weight of which is 30 kilograms (66 pounds) and which firmly imbeds every stone.

(H) What is the cost per cubic metre (1.308 cubic yards) of excavating soil for new roads?—Answer. For digging, shoveling out, and loading the average is 50 centimes (10 cents) per cubic metre (1.308 cubic yards). The transport expenses are calculated by the following formulæ:

$$\text{Wheelbarrow}: \times = \frac{2\text{-}p.\ d}{C\ D} \qquad \text{Cartload}: \times = \frac{P^{1}\ (2\ d + l)}{C^{1}\ D^{1}}$$

Wheelbarrow: P = price of a day's work; d = transport distance; C = cubical load ($\frac{1}{25}$ cubic metre); D = distance to run with wheelbarrow loaded half way and empty half way. Cartload: P^1 = hire of cart and driver; d = transport distance; l = distance 600 to 800 metres (119.304 to 157.072 rods), according to time lost in loading and unloading; C^1 = cubical load .7 to .8 cubic metre (.9156 to 1.0464 cubic yards) for one horse, according to the nature of the material; P^1 = distance to run with the cart during one day and when loaded half way and unloaded half way.

(I) What is the cost per cubic metre (1.308 cubic yards) of breaking stone to suitable size?—Answer. 1.75 francs (34 cents).

(J) What is the cost of the broken stone per cubic metre (1.308 cubic yards) placed on the new road?—Answer. 20 centimes (4 cents) for placing in the prepared form without roller. (NOTE.—Question evidently not fully understood.)

(K) What is the variety of stone so used?—Answer. Country flint, or the sandstone of May or Cherbourg.

(L) To what size is it broken? If more sizes than one are used, give extreme sizes and proportions of each as used.—Answer. Uniform size, the minimum 4 centimetres; the maximum 7 centimetres (that is about 1½ inches and 2¾ inches).

(M) What material is used to bind the broken stone, and in what manner and when is such binding material supplied?—Answer. Clay, sand, or earth from the excavation when such is suitable. These materials are put on after the steam-roller has been once over the road and then continued until complete aggregation.

(N) What wages are paid per day to common laborers employed in road making, and how many hours constitute a day's work?—Answer. Three and a half francs (68 cents) for 10 hours' labor.

(O) What is the total cost per kilometre (198.84 rods) of a section of new country road?—Answer. Twelve thousand francs (per kilometre) for all sorts of work which concern the establishing of a road like the type profile hereunto annexed. (NOTE.—This equals 70½ cents per lineal foot; \$11.64 per lineal rod; \$3,725.64 per lineal mile.)

(P) What is the average total cost of such a completed new road per square metre (1.196 square yards)?—Answer. The above price is to a minimum of 8,000 metres (square per kilometre of road distance) and gives 1.50 francs (39 cents) per square metre. (NOTE.—This equals \$7.32 per square rod.)

(Q) Management of road when completed, etc.

(*a*) For what length of time after completion is such new road permitted to be used without repair?—Answer. The roads are immediately put under constant supervision.

(*b*) In what manner is its cost paid; by whom?—Answer. The cost of the departmental roads is paid with part of the communal budget united with the departmental subsidy (approved budget by the general council).

The communal roads are paid for from an appropriation from taxes collected in the locality. (Approved budget by the municipal council.)

(*c*) In what manner are repairs paid; by whom?—Answer. The same answer as paragraph (*b*).

(*d*) What is the average annual cost for repairs of such a road per square metre?—Answer. Departmental roads, in country, 10 centimes (2 cents); in town, 17 centimes (3¾ cents); communal roads, 6 centimes (1½ cents). These prices include sweeping, removing mud, watering materials, and the maintenance of all works. (NOTE.—Aver-

age yearly expense of repair equals departmental roads. In country, $248.48. In town, $422.41. Communal roads, $149.09 per mile of road the width as considered.)

(*e*) What length of such road can one man keep in repair throughout the entire year?—Answer. Departmental roads, 4,000 metres (2.485 miles). Communal roads, 8,000 metres (4.97 miles).

(*f*) What yearly wages does such a man receive, he boarding himself?—Answer. The road men are employed 10 months per year, at an annual salary of 650 francs ($125.45).

(*g*) How many hours per day does he work?—Answer. Ten hours' labor.

(*h*) How many days of the year does he actually work on the road?—Answer. Two hundred and fifty days of labor (two months' leave of absence during harvest time).

(*i*) In what manner are the road engineers, superintendents, assistants, and workmen chosen?—Answer. The engineers, agents, clerks, etc., are chosen by competition. The road men and superintendents are generally chosen from among countrymen who know all about this kind of work.

(*j*) How much are they severally paid, how long do they serve, and by whom are they paid?—Answer. *The service organization.* One chief trustee of roads to the chief town of the department; one trustee of roads to the chief town of the neighborhood; one trustee of roads to the principal district of the neighborhood; one brigadier per brigade of ten roadmen to superintend 40 kilometres (24.8548 miles) of road. This gang has to do all that is required for the communal roads. The employed are paid from funds explained above. Salaries are as follows, viz: Chief trustee of roads, yearly salary is 10,000 francs ($1,930): trustees of roads, neighborhood, salary 5,000 francs ($965) per year; trustee of roads of district, 2,000 to 3,200 francs ($386 to $617.60) per year; employés, agents, 1,200 to 1,800 francs ($231.60 to $347.40) per year; chief road men, 900 francs ($173.70) per year. Indemnity of residence and office expenses are paid according to the importance of the locality. The employed have a pension after 30 years of service.

C.—Considerations in road making.

(1) The perpetual advantage of an easy grade should be secured at the beginning.

(2) Straight lines are best and on like grades are cheapest; it is economy, however, to secure easy grades at the expense of straight lines where such grade is otherwise unobtainable, because the perpetual advantage to all users of the road more than offsets the disadvantage to the land owner from ill-shapen fields.

(3) Capacious middle blind drains in all roads will dry the soil in summer and minimize the damage by frost in winter.

(4) Side drains should never be omitted.

(5) If natural soil of road be arched at center its drainage will be easier.

(6) All stones liable to disintegrate the road surface should be rejected.

(7) Comparatively large cost is unavoidable; cheaply made roads will prove the most expensive roads.

(8) Material should be carefully selected, durability and cheapness when prepared being first considered; then by using local stone local labor may be employed, and so by outlay for stone and labor each locality will to an extent be benefited directly by the distribution of the money cost of the road in such locality.

(9) The common field bowlder, more or less a nuisance on American farms, is of a strength and durability equal to the average quarry stone; both its purchase and removal would benefit the farmer and its preparation would benefit the local laborer, and thus go far to reconcile both to the expense of the improved road.

(10) Every county should own and operate at least one steam road-roller.

(11) Road sweepings, except manure, and common sand and clay make suitable binding material over broken stone.

(12) In making a new road wetting down or sprinkling has been proven injurious; such practice is wise in repair, as then the binding material is solidified while the water does not penetrate the surface coating to soften or weaken it.

D.—Considerations in road keeping.

(1) Repair should never be delayed.

(2) Scientific supervision is essential.

(3) Wetting down aids repair by helping the new added material to adhere to the old.

(4) For repair, especially of large areas, as well as for construction, a steam roller effects great economy.

(5) The use of wide tires should be encouraged either by bounty on such or by tax on narrow ones.

(6) Four-wheeled freighting vehicles should not track; the hind wheels should roll outside the track of the fore wheels.

(7) Local tax for maintenance tends to prevent local misuse, promotes local supervision, and prompts repair.

(8) Our people may, in order to equitably adjust cost of road, fix a tax upon their use so that he who drives much and owns little assessed property may pay a just share for the road he uses.

E.—General considerations of roads.

(1) Increase of railroad mileage seems to lessen local interest in highways, but it should not be forgotten that nearly all railroad freight has been previously carted over highways.

(2) As steam road engines become more in vogue, roads and bridges should be strengthened accordingly.

(3) As bicycles and other "wheels" become used by business men, roads should be fitted therefor to every reasonable extent.

(4) The use of springs on freight wagons greatly diminishes the jolt or falling force in road depressions, prevents ruts, and preserves roads.

(5) The effects of wheels of large diameter and width of tire is to greatly diminish spot pressure, and the breaking of the road surface is thus obviated.

(6) The reduction of cost of transit of persons and freight by lower prices for liveries and for hauling would be beneficial, and as transportation is a large element of cost to every one not a producer, good roads would much cheapen living.

(7) The cost of transporting products or of hauling to market is by tenfold the highest tax now paid by our farmers and hucksters.

(8) The cost of highway transportation over the properly built roads of France does not exceed one-third the like expense in the United States, it being common in the rural districts of France to haul 3 tons, and in the cities from 3 to 5 tons, net freight, with one horse.

(9) In this way the good road saves the farmer each year much more than its cost, and we may ignore the increased pleasure in its use.

(10) If 2 horses haul the load of 4, 1 wagon of 2, 1 set of harness of 2, 1 driver serve for 2, and if 6 miles instead of 3 be passed per hour, the aggregate saving would double the net income of the average huckster or farmer.

(11) Land values are increased by improved roads. This effects 1st, increased assessment and taxes on lands abutting because most benefited. 2d. This increased assessment reduces per cent. of tax and tax on lands not abutting, and which are hence less benefited.

BOUCHES-DU-RHÔNE.

REPORT BY CONSUL TRAIL, OF MARSEILLES.

HISTORY OF FRENCH PUBLIC ROADS.

The history of public roads in France dates back to the Roman occupation. So solidly did the Romans construct them that parts of a few of them are still to be found in a good state of preservation. They were made by the Roman generals to facilitate the rapid movement of their large armies. Thus the first roads made in France were for military purposes solely, and this object has never been lost sight of; so that, although in modern times their use as the means of communication for the people accounts for their great and increasing number, it is largely owing to their military character that the French Government expends the enormous sums it does yearly on the national roads.

After the Romans were driven out of France there is nothing to note on the subject of roads until the time of Louis XIV. This monarch had several fine roads made in the environs of Paris for his personal use and pleasure. They were very wide, probably so laid out from simple ostentation, and paved only in the center for the royal coaches. Shortly after the construction of these royal roads the nation began to appreciate the advantage of paved ways, as the use of vehicles was becoming more general, and the commencement was then begun by the French people of the magnificent network of public roads now to be seen covering the whole of France, and not equaled by any other country in the world. The roads of Louis XIV were made for the king by means of the corvées exacted from the peasants. At the present time they are for the peasants by means of subsidies and heavy taxes exacted from the government and the public. The corvée has degenerated into the three days of prestation. At the present time the public-road system in France is a luxury which the people can ill afford; but the peasant who derives the greatest benefit from it uses his political influence not only to see that the roads already made are maintained, but to cause the construction of new ones that are little needed.

There are five classes of French public roads: (1) The national highways; (2) the departmental highways; (3) the chemins vicinaux (country roads) de grande communication, maintained by the department under the direction of the conseil-général; (4) the chemins vicinaux d'interêt commun, maintained by the group of communes interested, and (5) the chemins vicinaux ordinaires, at the charge of each commune.

The highways are under the general control of the department of public works, which has an agent voyer in each department (state) to superintend all that concerns roads and bridges.

The five classes of roads finished in 1867 had a length of 323,400 kilometres, and of unfinished roads there were 281,100 kilometres.

The average outlay or first cost per kilometre for these roads was: for those of the first class, 20,000 francs; second class, 15,000 francs; third class, 10,000 francs; 4th class, 5,500 francs; fifth class, 4,000 francs; and the average cost of maintenance per annum per kilometre for the five classes was, for the first class, 600 francs; second class, 450 francs; third class, 306 francs; fourth class, 190 francs; fifth class, 140 francs.

So much for France at large. Three notes are added concerning the subject in the department des Bouches-du-Rhône, and three sectional drawings of roads in different parts of France.

DEPARTMENT DES BONCHFS-DU-RHÔNE.

The Department des Bouches-du-Rhône is about the size of the State of Delaware, with a population of 604,857. More than half this number, 376,143, are in the city of Marseilles. The population of Delaware is about 168,000, and of this number 43,000 are in Wilmington. The density of population for the Bouches-du-Rhône is 119 to the square kilometre, while that of Delaware is 32 to the square kilometre.

The annual expenditure for maintaining the highways and country roads in the Department is $456,000. This does not include the streets of Marseilles. It would be interesting to know the annual expenditure of Delaware on roads.

According to Adolphe Joanne there were in 1886 in the Department 4,329 kilometres as means of communication, to wit:

	Kilometres.
17 lines of railway	413
5 national highways	284
20 departmental highways	410
Country roads:	
Chemins vicinaux de grande communication	878½
Chemins d'intérêt commun	850
Chemins vicinaux ordinaires	1,352½
1 navigable river (Rhône)	85
3 canals for navigation	56

COUNTRY ROADS.*

In the Bouches-du-Rhône, as in all the departments of France, there are, besides the national and department highways, country or village roads, divided into three classes according to their importance: (1) Les chemins de grande communication; (2) les chemins d'intérêt commun; (3) les chemins vicinaux ordinaires ou de petite communication.

All these roads are made with layers of stone broken very small after the formula of MacAdam, and maintained by the application of new beds of broken limestone. The level of the roadbed is kept up by the constant use of the same material in filling in the unevennesses or irregularities that occur.

* The information in regard to country roads was kindly given to me by the prefect of this department.—C. B. T.

The road superintendents make the necessary repairs and look after the materials to be employed. The section of road that each one has under his charge varies in length according to the importance of the road from 5 to 10 kilometres (or from nearly 3 miles to 6½ miles).

Generally speaking the roads are made and maintained with the materials nearest at hand, and of these limestone is preferred.

The cost of road making in the Bouches-du-Rhône is on the average per linear yard, for les chemins de grande communication, 10 francs; les chemins d'inétrêt commun, 8 francs; les chemins de petite communication, 6 francs, 50 centimes.

The chemins de grande communication have a total length of 1,108 kilometres 140 metres (or about 700 miles), of which 999 kilometres 977 metres are in a perfect condition, and 108 kilometres 163 metres open for travel, but work on them not completed. They necessitate an annual outlay of 578,000 francs ($115,600), or 52 centimes (10 cents) per linear metre.

The chemins d'intérêt commun have a total length of 944 kilometres 468 metres, of which 756 kilometres 259 metres are in perfect condition, and 188 kilometres 209 metres open for travel, but work on them not completed. Their maintenance causes an annual expenditure of 256,500 francs, or 27 centimes (5 cents) per linear metre.

The chemins de petite communication have a total length of 1,012 kilometres 413 metres, of which 342 kilometres 442 metres are in perfect condition, and 669 kilometres 971 metres open for travel, but not completed. On these the sum of 351,800 francs is annually expended, or 34 centimes (7 cents) per linear metre. The commune of Marseilles alone expends on the chemins de petite communication 250,000 francs per annum.

It is certain that the effect of improved public roads has been to increase land values; but from the lack of statistics on this subject, there is no way of estimating just what this increased value may be.

The chemins vicinaux de grande communication and those of intérêt commun are made with the communal funds and the department subsidies, and in certain cases the national government also subsidizes these roads. The making of the chemins de petite communication is left to the charge of the communes, which are authorized to impose an extra tax of 3 centimes for this purpose to the principal of the four direct taxes.* The government and department also subsidize these roads.

As for their maintenance, this is provided for with special funds voted by the communes and the department. The department imposes an extra tax of 7 centimes to the four direct taxes, and the communes

*The four direct taxes: Les quatre contributions directes; savoir; la contribution foncière; la contribution des portes et fenêtres; la contribution personnelle-mobilière; et la contribution des patentes.

5 centimes and 3 days of prestation.* The maintenance of the chemins de grande communication et d'intérêt commune absorbs the 7 centimes from the department, two-thirds of the 5 centimes from the commune, and 2 days of prestation. This leaves for the chemins de petite communication one-third of the 5 centimes from the commune and 1 day of prestation.

HIGHWAYS.†

In the Bouches-du-Rhône the highways are paved or macadamized. Paving is used only where the traffic is very heavy or where the macadam would be difficult to keep in good condition and, consequently, too onerous. In some sections where the winds are very violent, the macadam has been found to be very objectionable on account of the dust and its wearing away rapidly when subjected to violent winds that blow continually for a certain length of time.

The paving is maintained in one of two ways. When the defect is only a slight one it is remedied by simply picking out a few blocks, releveling the bed, and resetting the same blocks; but when the damage is considerable and the road has been worn into ruts from rough and heavy use, the entire defective section is taken up and repaved with the same care given the original paving.

The macadam is maintained by constantly filling up any slight depression with the small broken stone in order to keep the level and to favor the regular use of the road. When the road is worn down quite thin an entirely new bed of stone is spread over it and pressed down and worked in by means of heavy rollers.

In the Bouches-du-Rhône the national highways have a length of 283 kilometres 848 metres. Over these pass daily, on an average, 688 horses. The annual expense for their maintenance amounts to 702,120 francs. The department highways are 413 kilometres 174 metres in length, and the daily travel on them amounts to 232 horses, and for their maintenance 391,470 francs are expended annually.

These highways are kept up by means of funds provided for in the budgets of the national government and the department. There is no prestation for these highways as there is for the country roads.

STREETS OF MARSEILLES.‡

In Marseilles the streets in which the traffic is heavy are paved with porphyry from the quarries of St. Raphaël, situated about a hundred miles to the east of Marseilles. This stone forms a very hard pavement that resists wear very well, but it has the inconvenience of becoming very

* Prestation: The 3 days of work on the roads that every proprietor, farmer, etc., is required to give free.—C. B. T.

† From information kindly supplied by the prefect of the Department of Bouches-du-Rhône.—C. B. T.

‡ From information kindly supplied by the mayor of Marseilles.—C. B. T.

smooth and slippery with constant use, and this can only be obviated to a small extent by using small stones, *i. e.*, cutting the squares down to small dimensions, in order to have numerous joints.

The streets in which traffic is light are paved with a stone called "Grés de la Ciotat," a hard kind of sandstone from the quarries of La Ciotat, situated about 30 miles to the east of Marseilles. This stone resists wear in lesser degree than porphyry (proportion 1 to 3.30), but not becoming smooth and slippery so easily, is used also wherever a steep incline in the street occurs.

Where an incline exceeds 7 per cent. the streets are macadamized. Side streets, where traffic is very light, and cross streets, are also macadamized.

The macadam is composed of a layer of about 25 centimetres thick (8½ inches) of calcareous stones, broken to 2 to 6 centimetres, from the quarries around Marseilles, and a thin layer of light quarry waste as surface binding material, the whole firmly compressed by steam rollers.

The cost of a street paved with porphyry amounts to 16 to 18 francs per square metre (say $3 to $3.50 per square yard), according to the size of the paving stones, including cost of all materials and labor. The cost of a street paved with La Ciotat sandstone amounts to 13 francs (say $2.50) per square yard, including materials and labor. The cost of maintaining paved streets averages 65 centimes per square metre per annum (say 13 cents per square yard per annum), but reaches 2.50 francs (50 cents) in streets where traffic is the heaviest.

The cost of St. Raphaël porphyry stone delivered in the city of Marseilles is, crude (rough hewn), 11 francs ($2.16), and cut to proper dimensions 13.20 francs ($2.55) per square yard; that of La Ciotat sandstone, crude, 6.60 francs ($1.28), and cut, 7.92 francs ($1.55) per square yard.

The cost of macadamized roads is as follows: The calcareous stones, broken and ready for use, cost 6 francs ($1.16) per cubic metre, and the cost of a road made of such stones, including layer of light stones, rolling, and all labor, amounts to 2.58 francs (52 cents) per square yard. But as the macadamized streets of Marseilles are generally bordered on each side with paving stones of La Ciotat sandstone, forming a shallow gutter about 2 feet 6 inches broad, in order that running water should not wash the sides away, the cost of such a macadamized street of 20 feet breadth, exclusive of sidewalks, amounts to 5.09 francs ($1) per square yard. The cost of maintaining a macadamized street averages 19 centimes for the materials and 14 centimes for labor, say 33 centimes in all, per square metre per annum (6½ cents per square yard per annum), but reaches 1.65 francs (33 cents) for streets that are very frequented.

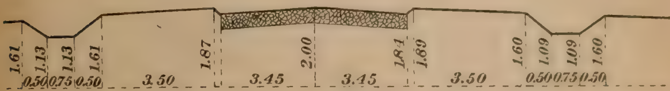
The city streets are maintained exclusively by the city funds (the city budget), and no special tax is levied for them, unlike village and country roads (chemins vicinaux), for which an additional tax is collected.

The foregoing estimates of cost do not include the value of the land occupied by the public streets, as same is too varied to be given accurately.

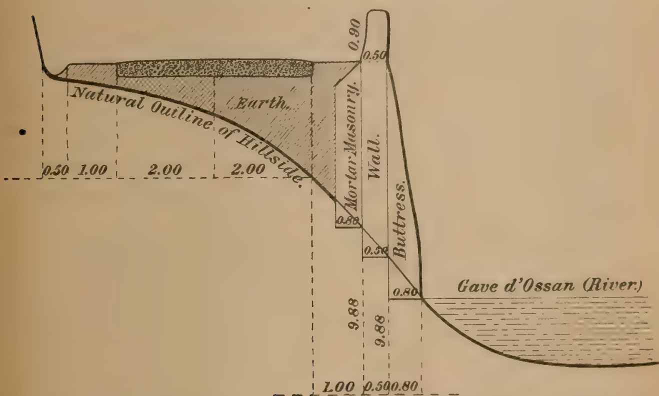
The following notes are sectional drawings of a national highway, a departmental highway, and a country road.

C. B. TRAIL,
Consul.

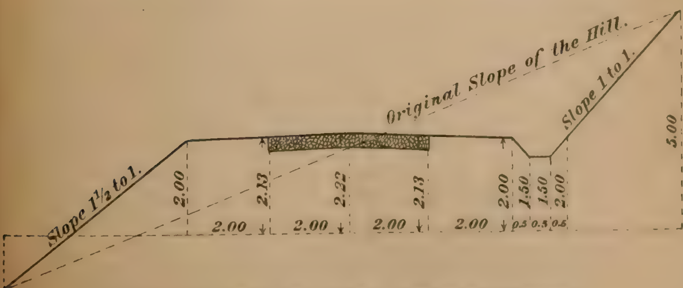
UNITED STATES CONSULATE,
Marseilles, March 4, 1891.



Section Route Nationale. No. 138. Department of Eure. (Measures and heights given in metres.)



Section, Route Départementale, No. 18, Basses-Pyrénées. (Measures given in metres.)



Section of Chemin Vicinal, Seine-et-Oise. (Measures given in metres.)

COGNAC.

REPORT OF CONSUL PRESTON.

In France there are three kinds of public roads: (1) The grand roads of the state, which are maintained at the cost of the state by a special tax; (2) the departmental roads, or roads of the departments leading from one principal town to another, are maintained at the expense of the departments, also provided for by a special tax; (3) the communal roads and streets of the communes, or cities and villages, are also provided for by a special tax on the inhabitants. Some of the city streets are paved with Belgian pavement, square blocks of stone; others are macadamized simply by covering with broken stone, which is soon worn down smooth by passing carriages, making a very perfect roadway.

In the country it is permitted to the inhabitants to make these roads themselves instead of paying a tax. In this district there is plenty of soft stone found along the roads, which, being broken up and spread over the roads once a year, generally in the fall, keep the roads in perfect order. I have never seen better country roads anywhere. The expense is trifling, the stone being found on the spot, and the day laborers' wages being small, say 2 to 2.50 francs per day.

The effect of good public roads upon land values is of course to increase the value of such lands, to what extent I am unable to say, as the roads all over the country, as far as my experience goes, are in perfect condition.

The country being so thickly settled, good roads are indispensable. I regret that I am unable to give any more particular information.

WM. S. PRESTON,
Consul.

UNITED STATES CONSULATE,
Cognac, December 17, 1890.

DEPARTMENT DU NORD.

REPORT BY CONSUL ATWELL, OF ROUBAIX.

COUNTRY ROADS.

In France roads may be classed in the order of their importance, as follows:

1. *National roads.*—These are the great arteries of the system, and connect the most distant points of the country. They are the property of the government, by which they are constructed and maintained.

2. *Department roads.*—These connect different points of the same department or of two adjoining departments. These roads belong to the department through which they run, and are constructed and maintained by funds appropriated by the department.

3. *Highways.*—Highways belong to the township or commune which they traverse. In theory these roads are built by the commune, but in point of fact they are made and repaired by the department from taxes levied on the commune, supplemented by a department subsidy. In the department du Nord this subsidy amounts to two-thirds of the cost of the maintenance of the road.

4. *Public roads,* the property of the commune through which they run, are made and repaired by the department in which the commune is situated from assessments on the commune and by a department subsidy. In the department du Nord the commune bears only one-half the cost of repairs. The common council establishes the rate and distribution of assessments for the purpose of building new roads.

5. *Crossroads.*—These are maintained by sums derived from the ordinary revenues of the commune, and when necessary by additional taxation authorized by law. In special cases the department makes a grant from funds appropriated for the maintenance of crossroads. The cost of building these roads is divided between the department and the commune, the department assuming four-fifths of the indebtedness, the remaining fifth being a charge against the commune.

6. *Country roads.*—These are kept in condition by the commune. When they are impaired by unusual traffic the town administration may claim an indemnity, which, in case of disagreement, is established by a commission named by the department.

Construction.—These roads are inalienable and imprescriptible. Public roads in general have a central roadway, the minimum width of which must be 3 metres or 3 yards 9 inches, bordered when necessary by lateral ditches. They are either of broken stone or of paving blocks. Wherever traffic is heavy blocks are employed; they rest upon a foundation of gravel, broken brick and glass, slag and sharp sand, the depth of which depends upon the nature of the soil upon which it is superposed. In a soil of sandy clay, like that of Roubaix, the foundation is from 10 to 12 inches in depth. The paving in use in this department is usually Belgian porphyry-granite from the Vosges and Brittany, and the different stones from the north, east, and northeast of France. The price per surface yard varies with the material employed.

Macadam roads, built wherever travel is light or wherever the cost of transporting the material would increase the cost of the road to too great an extent, consist of a layer of crushed material from 1½ to 2½ inches in depth, resting upon a foundation like that already described. This is packed down by steam rollers weighing from 10 to 15 tons. Under favorable conditions this road is rapidly made, is durable, and costs little for repairs.

CITY STREETS.

These are classified and private; the former belong to the city and are constructed and maintained by the city; the second are the prop-

erty of private individuals, who are compelled by law to keep them in good condition.

In the town of Roubaix macadam is employed for light travel and paving blocks for heavy traffic. The sidewalks are of sandstone and granite blocks or of cement or asphalt blocks.

The broken stone or macadam roads have a foundation of furnace refuse or broken brick from 10 to 12 inches in depth. Upon this is a layer of silicious gravel from St. Omer, or, better still, broken porphyry from the Belgian quarries, worth $2.56 the cubic metre. The average price of macadam roads may be estimated at $1 the surface metre. The work of repairing is met by a general assessment and is relatively high in Roubaix on account of the defective manner of construction owing to the employment of rollers of too little power.

Paved streets are upon a foundation like the above, about 10 inches in depth and worth 38 cents, American value, the cubic metre; this foundation is covered by a layer of sand 4 inches deep, at $1.14 the cubic metre; paving blocks are then pounded into position by a paving beetle weighing 10 kilograms. The material in use in Roubaix comes from the granite quarries, situated in Pas-de-Calais, Ardennes, and in the neighborhood of the Oise and Vosges. The price per surface metre may be estimated at about $2.09.

These paved streets are kept in condition by taking them up in part or whole. As a rule, the blocks keep their place well and where there is a slight depression workmen are employed to raise the block and put sand underneath; when the depression is general, the street is torn up and remade upon a new foundation. In the first instance, the workman receives a trifle less than 3 cents, American value, the square yard; in the second, he is paid 9 cents per square yard. The materials are estimated apart and paid by the cubic metre.

For the above information I am indebted to the supervisor of streets and engineer of roads and bridges.

W. P. ATWELL,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Roubaix, February 2, 1891.

NANTES DISTRICT.

REPORT BY ACTING CONSUL BENNETT.

COUNTRY ROADS OR HIGHWAYS.

The routes, country roads, or highways of this consular district are most excellent and well worthy of study and imitation. They are made for heavy or light traffic, are as smooth as asphalt, and nearly as solid and durable as granite. It has evidently required many years of toil

and experience to arrive at the state of semiperfection in which we find the roads at present, but notwithstanding the time required and labor expended the results are most satisfactory.

Each state or department has charge of its own highways, the construction and maintenance of which is confided to a chief surveyor of the highways, who is under the direct authority of the prefect of the department. There are two or three classes of roads, the making of each being essentially the same, varying only as to width and as to details of maintenance. For the practical purposes of this study we will class them as two only, the large national or departmental routes, and the vicinal or rural roads connecting village with village, or making connection with the large national thoroughfares. The departmental routes are 8 metres in width, the rural roads 6 only; the making of the two roads is the same, but the maintenance of the national roads is often the more carefully attended to.

The methods adopted in this consular district for the making of roads are briefly as follows: After the survey and tracing of the line, the ground is carefully leveled and graded as much as is possible to avoid too abrupt ascents and descents. If a wide road of 8 metres is being made, a trench 4 metres in width and 7 or 8 inches deep will be excavated in the middle, leaving for walks a space of 2 metres on each side; this trench is filled with broken stone—stone broken to about the size of 1½ inches square. This mass of broken stone is then solidly forced into position by the use of heavy iron cylinders, which are rolled backwards and fowards over these stones until they become settled into one solid mass, smooth and durable.

These iron cylinders when empty weigh from 2,800 to 3,000 kilograms (6,150 to 6,600 pounds), and are sufficiently large to admit of an equal weight of stone being packed in the interior, which makes, when ready for use, a weight of from 12,000 to 13,000 pounds.

A transversal diagram of a road as made here would be something like the following:

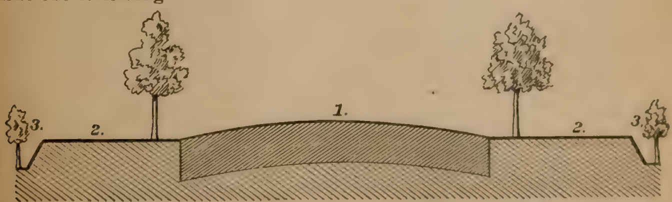


Fig. 1 representing the roadbed of broken stone, slightly rounded; figs. 2, the walks on each side usually shaded with trees; figs. 3, a ditch and hedge or stone wall, as the case may be.

The first cost of making a road of this class is from $1.25 to $1.75 per square metre, the price varying according to the amount of grading required and to the facilities of procuring the proper kind of broken stone, for it seems that some kinds of stone give better results than

others. A species of quartz gives the best results as to uniformity and durability. Within 1½ miles from Nantes is found an immense granite quarry, which furnishes excellent blocks for monuments, building purposes, etc., also small blocks for city street paving, where it resists in a manner perfectly satisfactory; but this same granite, broken small and pressed into a roadbed, is soon reduced to powder under heavy traffic and is often in need of repair, while quartz resists satisfactorily for a number of years.

The system employed in this district for maintaining the roads in good condition is very simple and inexpensive. The roadbed is allowed to wear away some 2 or 3 inches, when a new layer of broken stone is brought into requisition in the same manner as at first, they being pressed into uniform smoothness by the use of the heavy iron roller. This repairing is more successful when performed during the rainy months of the winter season.

The cost of repairs is about 5 cents per square metre.

H. D. BENNETT,
Acting Consul.

UNITED STATES CONSULATE,
Nantes, February, 1891.

PARIS.

REPORT BY CONSUL-GENERAL KING.

Kind of pavement.	Surface, Jan. 1, 1890.	Kind and thickness of foundation.	Kind and thickness of materials forming revetment.	Average price per square metre.	
				First establishment.	Annual expenses, including general repairs.
	Sq. metres.			*Francs.*	*Francs.*
Stone	6,336,900	(1) Sand 20 to 30 centimetres in thickness. (2) Concrete of lime, 15 centimetres in thickness. (3) Concrete of Portland cement, 15 centimetres. (4) Ballast, rolled, 15 centimetres after rolling.	Paving stones of hard sandstone, of "arkose" of granite, and of porphyry, as follows: Large: Length, 23 centimetres; width, 16 to 23 centimetres; height, 23 centimetres. Medium: Length, 16 to 20 centimetres; width, 14 to 18 centimetres; height, 16 to 20 centimetres. Small: Length, 16 to 20 centimetres; width, 12 to 14 centimetres; height, 12 to 18 centimetres.	20.00 24.00 24.50 24.00	0.74
Wood......	484,900	Concrete of Portland cement, 15 centimetres in thickness.	Blocks of wood: Length, 17 to 27 centimetres; width, 8 centimetres; height, 15 centimetres.	20.50	2.50
Asphalt ...	301,400	Concrete of Portland cement, 15 centimetres in thickness.	5 or 6 centimetres after being rolled.	Thickness of 5 centimetres, 20.50 francs; thickness of 6 centimetres, 21.50 francs.	2.00
Gravel.....	1,510,200	This pavement, or roadway rests directly on the soil in which the gravel packing is placed.	Porphyry, millstone, pebble, 25 to 30 centimetres in thickness.	Porphyry, 8.30 francs. Mill-stone, 6.65 francs. Pebble, 4.65 francs.	3.70 2.47 1.30

Stone.—The cost of stone pavement on sand foundation varies from 16.60 to 24.80 francs. The extremes of these prices correspond to specimens of paving stones which are now only exceptionally employed. The same holds good for the three other kinds of pavement for which the average prices only differ from the figure of 20 francs by reason of the supplementary cost for the foundation. The pavements on concrete or on rolled gravel (the latter are rarely adopted) have been made only a few years ago, and form but a relatively small surface. The trials had with these revetments up to the present time are not yet conclusive enough to allow a possibility of pronouncing definitely on the advantages and inconveniences they present. However, the results obtained up to date seem to indicate that recourse should be had to solid foundations only in the three cases following: (1) When the soil is clayey or insufficiently resistant; (2) when there are lines of tramways; (3) when the circulation or traffic is very intense and at a rapid pace. It is now considered as indispensable to interpose between the foundation and the pavement a layer of sand of 5 to 10 centimetres in thickness.

Wood.—The extremes of the prices paid to the lessees who have constructed these pavements under contract, and who keep them in repair under the same conditions, are 2.08 and 2.95 francs for each of the 18 annuities, comprising, moreover, not only the ordinary keeping up, but also the repairs throughout the duration of the contract. The new wooden pavements are now constructed and kept up, with very rare exceptions, exclusively under the self-management ("*régie*") of the city of Paris, which realizes by this combination an economy of about 15 per cent. on the average price of 20.50 francs indicated under this heading. The paving blocks rest always directly on the foundation, which is covered over with a smooth plastering.

Asphalt.—The asphalt pavement is kept in repair by the contractors.

Gravel.—Porphyry and millstone do not always form the total thickness of the road. This is generally composed of a first layer of crude pebble 15 to 20 centimetres thick laid on the soil, and of a second layer about 15 centimetres thick, either of porphyry, millstone, or pebble. It is the second layer that gives its name to the revetment.

ADAM KING,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Paris, January 11, 1891.

RHEIMS.

REPORT BY CONSUL ANGIER.

CITY STREETS.

Generally in the cities and towns of this consular district the streets are substantially and beautifully paved with granite "Belgian blocks" from the famous quarries of "Vosges," a department of France in this

consular district bordering Alsace, the granite being of excellent quality and lasting a long time.

The manner of constructing these streets is as follows: First an excavation is made to the depth of about 16 inches from the proposed surface of the street when finished; a sand foundation or bed is then thrown in to a depth of 8 inches (the soil here is of chalky formation, well disposed to hold the sand well, without any primary layer of tar and gravel) and then the Belgian blocks are carefully laid on the sand. These Belgian blocks are 8 inches in depth, 6 inches in breadth, and 6½ inches in thickness. A heavy granite curbing, a little raised from the street, is the dividing line between the street and the "sidewalk." The "sidewalks," by the way, are paved much in the same manner as the streets. After the Belgian blocks have been laid in the streets, sand is thrown on to the depth of about ½ an inch, which is swept and reswept, back and forth, with heavy brush brooms, until every crevice and interstice between the blocks is filled. In a few months afterwards sand is again thrown on and the sweeping process renewed until the whole is very compact.

A street made in this manner will last from 30 to 40 years, very little repairs needed, and costs $3.17 per square metre (a square metre is 10.7642 square feet), the cost divided as follows:

31 Belgian blocks	$2.52
Sand	42
Labor	23
Total	3.17

The land owners are not required to pay any proportion of the cost for making, paving, and maintaining the streets, but are required to pay one-half of the expense for making and paving the sidewalks.

COUNTRY ROADS OR HIGHWAYS.

In the open country the main highways used to be paved, as are the streets now in the cities, but this was abandoned years ago, and the roads are now made simply of crushed stones of an average size of 4 inches, and then the heavy "steam roller-crusher" is run over it, back and forth, several times. Sometimes when the natural soil is not compact or solid enough, a good foundation is made for these crushed stones, but this does not occur often in this section. This foundation, when needed, may be quite a pavement of rough stones, or sometimes only a bed of sand or gravel is used for a foundation in places where it is sought to preserve the underground from the frost.

The main highways are Government roads, and were constructed and are maintained by the departments of France in which they are located and through which they run, and cost in this department (Marne) an average of about $9,300 per mile for their first establishment or construction.

The smaller roads are maintained by "la commune" (the people) through whose lands the roads run, and cost about $3,200 per mile for their primary establishment and construction.

The maintaining of the Government highways in good condition requires about 850 cubic feet of broken stones per mile per annum. The broken stones (or ballast) used for this purpose are obtained either from the flint stone quarries in the mountains near Rheims, or from quartz brought from the department of Ardennes.

The statements made in this report and the figures given may be relied on as quite acurate, nearly all of my data of information having been obtained from the Government engineer of bridges, roads, streets, and canals, having charge and control of all the bridges, roads, streets, and canals in a part of this consular district.

Though I have tried to get the information on which to base a report as to "the effect of improved public roads on land values," I can not make any report on that point. I am writing of roads located in and running through a country that, it is said, was overrun by the soldiers of Julius Cæsar, 50 years before Christ, and a later effort of the same sort, it is also said, was attempted in the fifth century by the Huns, from the shores of the Caspian Sea, under the leadership of Attila, and these roads have been maintained in their present good condition for so long a time it is difficult to approximate their effect upon land values.

ALTON ANGIER,
Consul.

UNITED STATES CONSULATE.
Rheims, December 22, 1890.

GERMANY.

AIX LA CHAPELLE.

REPORT BY CONSUL ZEIGLER.

CITY STREETS.

They are built of hard sandstone, where level or nearly so, but for heavy grades of somewhat softer quality. They are built and kept in repair by the city, and a general tax is levied for that purpose.

The stone used have a surface of 4 by 6⅜ inches by 7 inches deep, and about 45 are laid to the square yard, in courses across the street.

The foundation is of sand, about 8 inches deep.

The stone is hauled 6 miles by team, is cut by hand to the proper size, and costs the city, delivered, $1.82 per square surface yard.

The laying of stone and sand furnished is usually done by contract, at a cost of 42 cents per yard, making total cost $2.25.

All new streets are built alike, whether for light or heavy traffic.

The sidewalks vary from 2 to 12 inches above street, with curb-stone 7 inches wide and of various depths, and foundation consists of cement 4 inches thick or deep, covered with sandstone 4⅝ inches square by 3½ inches deep.

This is a very ancient city, and many of the old streets and sidewalks are made entirely different from the foregoing.

It is impossible to obtain figures as to cost of repairs.

As a rule, but very little is required for many years after a street is newly built, no matter how heavy the traffic, as they are well made, and I am informed that in many cases where streets were built over 50 years ago but few repairs have been needed.

The tires used on wagons for heavy traffic are usually about 5 inches wide, which may, to some extent, account for the durability of the stone on the street bed.

The city pays its laborers who repair streets from 60 cents to $1 per day of 9 hours.

COUNTY ROADS OR HIGHWAYS.

There are eight main roads leading out from this city, but no one living here now can remember of either one of them being built.

They are hundreds of years old, built by the Government, and kept in repair by it.

Four of them are constructed, quite a distance, the same as the city streets or nearly so, and cost of same would be, say, $2.25 per square yard.

The others are macadamized about 7 inches deep, with small, hard sandstone, and present cost to construct or build would be 45 cents per square yard.

They are kept in repair by supervisors, appointed by the Government, for the various road districts, with but little expense.

It would be impossible to give any data or figures as to effect of improved roads upon real estate or the surroundings, all having been built so long ago.

S. B. Zeigler,
Consul.

United States Consulate,
Aix la Chapelle, December 30, 1890.

BAVARIA.

REPORT BY CONSUL BLACK, OF NUREMBERG.

STREETS OF NUREMBERG.

The streets of the city of Nuremberg which are located within the old walls are all paved; those outside are only paved where the traffic on them is extraordinarily heavy.

The entire paved area is 583,875 square yards. Granite and sandstone (quartzite) are the materials which have been mostly used, for the last 15 years the former has been exclusively used. It is brought from the Bavarian Mountains.

The granite paving stones are of a shape resembling a parallelopiped, with sharp corners, having a length of from 6 to 8 inches, a width of from 5½ to 6¼ inches, and a height of from 5½ to 6 inches. The tops and sides have a smooth finish, the bottoms are more roughly cut; they must be flat, however, and never more than 1¼ inches smaller than the tops.

These stones are of the hardest blue granite, and cost $1.57 per 1,550 square inches free Nuremberg. All the material used in paving the streets is supplied by the city; in fact, it does all the work with the exception of the actual laying of the stones, which is given out to contractors.

The paving sand is a clayey kind of arenaceous quartz peculiar to the Pegnitz Valley, and the place from which it is obtained is the property of the city. The sand under the stones is loosely spread, at a thickness of from 6 to 8 inches.

The cost of paving with granite block of a street already opened, including all work and material, is $1.98 per 1,550 square inches. In the year 1889 there was expended for paving streets not previously paved the sum of $38,841.60, and during the same period, for repairing, the sum of $17,136 was expended.

There are macadamized streets in the new portion of the city to the extent of 503,516 square yards. These streets have been opened from time to time as the growth of the city demanded. The owners of the land through which they run are not only compelled to cede the bed, but are also required to bear the expense of making the street. The amount assessed to each property-holder is reckoned according to the size of his holdings; the amount charged per yard varies according to the size of the street. Contractors desiring to have a street opened in order to erect houses thereon must deposit with the authorities a sum equal to the whole cost of making the street, and until this condition is complied with the building permit is not granted.

The foundation of such streets consists of a layer of 6 to 8 inches of quartzite, a sandstone which is quarried at Wendelstein, near Nuremberg, and upon this a layer of Jura limestone 6 to 7 inches thick is placed. The whole is then thoroughly rolled with a large cylinder (pulled by horses) weighing 14,330 pounds. The cost of such a roller is $500.

The curbing used is hard granite. The gutters are 19½ inches in width and are paved with granite stones.

The foundation stones cost 71 cents per 1,308 cubic yards, the small broken Jura limestones $1.43 per 1,308 cubic yards, and the curbstones $1.04 per 3.28 feet, all free Nuremberg.

These streets vary in their width from 18.04 feet to 64 feet, and cost from $7.10 to $10.90 per width of 3.28 feet running across the whole street.

Repairs of macadamized streets are never made with Jura limestone, basalt always being used for that purpose.

The cleaning of paved streets up to 26.25 feet from the footway falls upon the owners of the adjoining property; any over that is done by the city. A few streets where the traffic is very heavy are cleaned entirely at the expense of the property-owners.

Macadamized streets are cleaned at the expense of the city. For this purpose the city is divided into fifteen districts, each district having an overseer.

In autumn and spring he has two assistants. The removal of the dust and dirt from these streets is done by contractors. The city pays for the same according to the distance hauled and the size of the carts.

No special mechanical methods are used. In the year 1889 the cost of cleaning macadamized streets was $7,473.

Footways.—Footways vary from 3.28 feet to 16.4 feet in width, according to the width of the street. Curbstones are laid at once upon the opening of a street, but the paving of footways is only required when the city deems there is a need for it, and that work is done at the expense of the owner of the adjoining property.

In the old streets where new curbstones are required the expenses for the same fall half upon the city and half upon the owner of the property, while the cost of the pavement is entirely upon the property-owner.

The footways when paved are done with cement and clay plates; when not paved they are generally made of clinkers. No asphalt is used excepting upon some iron bridges.

As a rule, proprietors of adjoining land pay for the cleaning of all sidewalks.

HIGHWAYS.

The highways within the limits of this consulate are of a width of from 13.12 feet to 23 feet, according to the traffic passing over them, and have upon either side footways of from 3.28 feet to 5 feet in width.

The foundation of these roads consists of hard stones which are never affected by the weather. They are separately set one by one, points upwards, and are of a length of 7.87 inches. Upon this is placed a layer of small pieces of basalt or Jura limestone of a thickness of from 3.93 inches to 5.91 inches, the former stones being used for highways upon which there is a heavy traffic, the latter upon those where the traffic is light.

Basalt is broken by special machines into pieces varying in size from 1.18 inches to 1.77 inches in diameter. That used here is broken by the Basalt Company, Limited, located at Steinmuehle, near Bayreuth, in

Bavaria. The cost at the factory is $1.70 per 1.308 cubic yards; the cost including that of delivering at the place where they are to be used is from $2.45 to $3.18 per 1.308 cubic yards.

Jura limestone is delivered in larger pieces than basalt and is broken into small pieces by means of steel hammers at the place of delivery. The cost of same is from $1.43 to $2.14 per 1.308 cubic yards, according to the distance of the quarries from the place of destination.

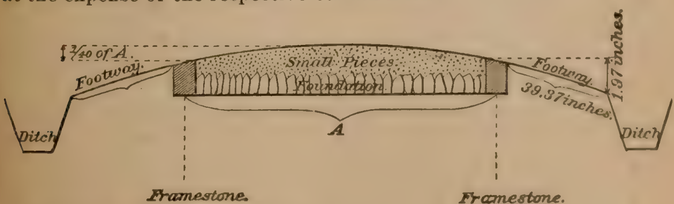
Small piles of these stones for repairing purposes are constantly kept upon the sides of the highways. The work is usually done in the spring or autumn, when the ground is soft and moist. The roads are thoroughly scraped and swept before the stones are spread, which is usually of a thickness of from 1.18 inches to 2.36 inches. They are loosely but evenly thrown on and the traffic is depended upon to work them into the ground. If this be heavy, the road is made smooth in two or three days, but if light, two or three weeks are liable to be consumed in getting the material well worked in. The roadway is constantly dressed in this manner until it becomes perfectly level. Should it happen, however, during this time before the stones are well set that frost or dry weather should render the ground impervious, all the loose new material is removed and not again spread until the weather becomes wet and the ground soft.

The roadway is bordered on either side by what are called "frame stones." They are very hard and are not influenced by the atmosphere. The depth at which they are planted is 11.81 inches; their width is 3.93 inches. The footways of 39 .37 inches in width have an incline of 1.97 inches.

I give you herewith a rough sketch of a highway which will elucidate more fully what I have written.

These methods apply only to the main highways, which are kept up at the expense of the state. In the hands of an experienced staff the best results are obtained. Practice, however, is necessary, in order to become acquainted with the best time and manner in which to spread the stones.

Cross-roads are, as a rule, not macadamized, and are kept up by and at the expense of the respective communities.



UNITED STATES CONSULATE,
Nuremberg, March 10, 1891.

WM. J. BLACK,
Consul.

BERLIN.

REPORT BY CONSUL-GENERAL EDWARDS.

The laying out and building of new streets within the city limits is a public interest only so far as the existing streets no longer suffice for the requirements of traffic and intercourse.

Nevertheless the street commission of the city of Berlin has been for many years extending the paving in a large circuit where it was not a public interest.

So long as the proprietors of land situated on proposed streets represented on the building chart of the city could build houses without considering if the streets were paved, if they were drained, if they were connected with an actual street, conditions were bound to arise which were very inconvenient for the inhabitants of such houses.

They regarded it as an injustice that they should not enjoy the same privileges as other citizens, and by their petitions exerted such a moral pressure on the communal authorities that their demands were granted.

A change could first be made after the passage of the law of July 2, 1875, concerning the building and alteration of streets and squares in towns and country places, and of the local statute of October 8–November 19, 1875, and after the issuance of the police regulation of September 12, 1879.

While under the cabinet order of December 31, 1838, proprietors of land bordering on newly paved streets were responsible only for the expenses incurred by the community in building such streets, they are now legally held for almost the entire sum expended by the town in finishing the street, and especially for the costs arising from the purchase of the street surface. As furthermore the building of dwelling houses is permitted only in such streets as are entirely paved and suitably drained, it is in the interest of the land owners, if they wish to use their property in this way, not to wait until by chance the streets on which their property lies are paved by the municipal street commission, but to have this work done themselves.

That the effect of this law upon the extension of municipal and private streets has been gradual is due to the fact that there was a considerable number of streets in which dwelling houses had been built prior to the passage of this law still to be put in order, and, on the other side, that it required a number of years before land owners realized that in consequence of the new law it was in their interest of their own accord and without municipal assistance to build the streets on which their property was situated.

How important, however, with time the effect has been can be seen from the following table, which exhibits construction and expense from 1882 to 1889, inclusive:

Year.	For account of—		Total.	Amount of expenses incurred by the city for paving streets.
	The city.	Private persons, street-car companies, etc.		
	Sq. metres.	*Sq. metres.*	*Sq. metres.*	*Marks.*
1882–'83	34,233	11,949	46,182	469,561
1883–'84	32,158	6,294	38,452	474,181
1884–'85	13,939	12,781	26,7_0	236,264
1885–'86	14,709	17,919	32,628	282,625
1886–'87	*42,980	34,849	†77,829	925,863
1887–'88	26,260	26,656	52,916	449,053
1888–'89	33,350	59,686	93,036	‡575,953
Total	197,629	170,134	367,763	3,413,500

* While heretofore private streets were often constructed by the municipal street commission at the expense of the private parties concerned, in later years this custom has been abandoned. Only pavings which are to be made simultaneously by street car companies and by the city are laid by the latter at the expense of the former. From other parties constructing streets, for superintendence of the work by the city street commission, a charge of 20 pfennige per square metre of paving is collected.

† In this sum is included the paving of York street, which alone represented an area of 23,452 square metres. Of this, 16,929 was constructed by the city at its own cost, and 6,523 square metres at the cost of the "Great Berlin Street-Car Company."

‡ The amount expended by the city in the year 1888–'89 for paving can not yet be stated exactly. From the fiscal balance, however, it may be estimated at about 576,000 marks.

If the subject of private paving is considered, it will be found from the above table and from the table already published for the years 1877 to 1881, that there has been considerable fluctuation. While the years 1877 to 1880 showed unusual activity on the part of private persons in this direction, in these 4 years 127,346 square metres of paving were laid at the expense of private parties, making an annual average of 31,836 square metres. In 1881 the amount fell off to 3,900 square metres, and from this time on it has risen to 60,000 square metres in 1888–'89.

This rising tendency, moreover, at present seems to continue, as is shown by the applications already received by the municipal street commission.

The number of streets proposed in the first three quarters of the year 1889 for paving in this manner was 21. Their total length amounts to 6* kilometres, and their total area to about 69,000 square metres.

Nevertheless the expenses incurred by the city for new pavings amounted in the 7 years covered by the above table to about 3,410,000 marks, or an average of 487,000 marks per annum.

These expenses naturally are really only outlays, as proprietors of land bordering on such streets upon building on their property must

* The completion of these streets by private speculators would add 12 kilometres to the street fronts of the city, while the streets finished by the city and by private persons between 1882–'83 and 1888–'89 have a length of 40 kilometres or about 6 German miles (over 25 English miles).

pay the expenses already incurred by the community in constructing the street.

The following table shows the amount paid into the city treasury under the statute of March 7, 1877, by land owners for the opening of new streets, as well as under cabinet order of December 31, 1838:

Year.	In accordance with—	
	Statute of March 7-9, 1877.	Cabinet order of December 31, 1838.
	Marks.	*Marks.*
1882-'83	95, 930	109, 493
1883-'84	100, 674	57, 383
1884-'85	80, 523	50, 395
1885-'86	100, 258	14, 669
1886-'87	211, 388	13, 827
1887-'88	227, 840	17, 966
1888-'89	416, 092	16, 742

If the figures of column two of the above table are compared with those of the last column in the preceding table, it will be seen that in no year has the amount paid into the city treasury under the statute of March 7, 1877, equaled the amount expended by the city in paving streets. In making this comparison it must be remembered that in accordance with the provisions of the statute, when streets are more than 26 metres broad, the area beyond this breadth must be paved solely at the expense of the community. Also with such parts of streets as border on tracts which by law or nature are not capable of being built upon, open squares, promenades, parks, railway stations, water courses, etc., no claim can be made by the city for recompensation beyond this limit.

The sums given in column two of the above table represent not only the amounts repaid to the city for expenses incurred in the purchase of the land on which the streets are constructed, but also construction and first paving costs. Yet the latter are not fixed for persons building on the street exactly in accordance with the amounts in the bills, but at a price per square metre which is fixed every year by communal order. This price differs for principal and side streets, and it can not exceed the cost of the lowest quality of paving permissible for such streets.

At first the price unit per square metre of paving was fixed at 11.50 marks in side streets and 13 marks in principal streets.*

These prices were originally adopted because it was thought that they would approximate but never exceed the actual cost price. Ten years' experience has, however, shown that these price units fall considerably behind the real cost. Accordingly, the prices have been raised to 13 marks in side streets and 14 marks in principal streets.

In similar manner payment of the costs of drainage is regulated where such in new streets is obtained through connection with the gen-

* These are such in which the paving rests upon a rolled substructure, such as is used for public highways, while in the side streets the substructure is merely a gravel bed.

eral municipal canalization. The land owners in new streets could not well be asked to pay the costs of an entire radial system which, perhaps, had come to be a necessity, without regard to the new streets. In like manner the amount actually expended in this way could not be charged to the persons having property bordering on such streets, because the land owners on the streets near the pumping stations would be burdened with the cost of the expensive masonry canals, while persons having property in the upper part of the radial system would have to pay only for the construction of the much cheaper earthenware tube drains, although these would be useless without the costly canals.

It had been learned from the canalization commission that in radial system III—which is relatively the cheapest of the systems—exclusive of the cost of the pump station and the forcing-pipe connections, the cost of the drains was 4,154,073.44 marks. As the street front in this radial system amounted to 78,443 metres, the cost per metre was 52.96 marks. Hence it was decided on February 29, 1884, whenever, upon building, the repayment of these costs becomes due, in such streets in which drains are laid simultaneously with or soon after the paving, the sum to be paid is 50 marks per metre of street front.

If the foregoing tables show that the activity of the municipal commission in laying new pavings has, since the second half of the decade beginning with 1870, materially deceased, yet since the same period in the matter of repaving there has been an enormous increase.

With the transfer of the streets to the municipality in 1876, on account of the increased traffic and the growing demand of the public, it became necessary to begin replacing with good suitable paving the old paving, which was almost all very bad, most of it having been laid during the first half of the century.

In the years 1877–'81 the average annual amount of bad pavement replaced by good was 55,200 square metres. In the period 1882–'89 this annual average has increased to 133,630 square metres.

The following table shows for the separate years the area repaved, and the amount paid out by the city for the purpose on its own account and for the account of street-car companies, the latter being responsible for the costs of paving between and near the rails in those streets in which, simultaneously with the repaving, the laying of the tracks takes place :

Repaved in the year.	For account of city.			For account of street-car companies.			Total.	Cost of repaving for account of city.		
	Asphalt.	Wood.*	Stone.	Asphalt.	Wood.*	Stone.		Wages.	Stone.	Total.
	Sq. met.	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Marks.*	*Marks.*	*Marks.*
1882–'83 ...	55, 445	7, 306	27, 238	7, 669	888	11, 121	109, 667	958, 531	639, 913	1, 598, 444
1883–'84 ...	63, 764	11, 837	43, 649	1, 570	4, 361	8, 527	133, 708	1, 815, 271	597, 750	2, 413, 021
1884–'85 ...	71, 971	3, 028	46, 725	1, 838	3, 197	5, 313	132, 072	1, 353, 766	818, 892	2, 172, 658
1885–'86 ...	36, 943	1, 319	41, 083	496	380	31, 057	111, 278	1, 261, 535	944, 924	2, 206, 459
1886–'87 ...	50, 041	3, 945	91, 689	4, 555	8, 647	19, 379	178 256	1, 266, 478	1, 146, 900	2, 413, 378
1887–'88 ...	71, 400	1, 631	46, 479	17	55	3, 210	122, 792	1, 698, 801	740, 031	2, 438, 832
1888–'89 ...	77, 402	1, 757	52, 950	5, 324	....	10, 232	147, 665	1, 785, 140	927, 631	2, 712, 771
Total ..	426, 966	30, 823	349, 813	21, 469	17, 528	88, 839	935, 438	10, 139, 522	5, 816, 041	15, 955, 563

*Under the date of April 17, 1891, Consul-General Edwards sent the following, translated from a Berlin journal: It is reported that the wood pavement, which was laid in many streets of Berlin, has worn so badly that the municipal street commission has decided to entirely stop using this material for paving purposes. Every sort of wood which has yet been tried has rotted in a comparatively short time, and its upper surface has become so much injured that repairs are hardly possible. Also, the horses fall upon it much more easily than upon asphalt pavement.

For this reason, "The Great Berlin Horse Car Stock Company's" petition that the space between the rails of its tracks on Spandaüer and König streets be repaired this time with asphalt has been granted, and this work will be finished during the coming summer.

Large as is the sum thus used, nevertheless, in view of the immense old tracks to be repaved, the fraction repaved each year is small. Hence, the deciding* each year which streets are to be repaved in the following year is very difficult, and the solution of the difficulty is not rendered more easy by the fact that, year in, year out, countless petitions are received, in which officials, societies, real-estate owners, and residents declare that exactly that street in which they live or carry on business is one of the very worst in the city, and that they must consider it an unfair distinction in favor of other taxpayers if their application does not receive immediate attention.

From the foregoing table it will be seen that of the materials used in repaving, the principal was asphalt, although the excess of this material over stone was small. In the years 1882–'89 over 448,000 square metres of asphalt paving were laid, while over 438,000 square metres of stone paving were laid in the same period. The victory of asphalt is due to the silence which prevails in the streets which are paved with it, to its comparative cheapness as compared with stone paving, and most of all to its great popularity with the public.

Asphalt pavements.—On account of the great importance which this sort of paving has won in Berlin, the following remarks in regard to its technical preparation may be found of interest:

In laying asphalt pavings in Berlin the heated asphalt powder is poured over the previously prepared concrete sub-bedding, and by beating or rolling is reduced to a surface unbroken by seams. Since the year 1887 this work was done by four contractors only, who used asphalt stone from Bal de Travers in Switzerland, Pyrimont-Seyssel in France, and Ragusa in Sicily, and, as their bids were the same, the areas to be

* This decision was formerly made by the street commission, but for several years it has been made by the city council.

paved were given out in equal parts. To these contractors—of whom the one who used stone from Pyrimont-Seyssel has entirely given up street work—recently three new ones have been added, one of which—an English stock company—uses limestone from the quarries of St. Jean Marméjols, Department Gard, France, while the other two, local manufacturers, use asphalt, manufactured the one from Sicilian stone and the other from stone found near Ancona in Italy. As the new contractors have made decidedly lower offers for the sample pavings undertaken by them than the prices of the older contractors, it is to be hoped that in future the municipal street commission will succeed in having all its asphalt paving done at reduced rates, and in this way, without increasing expenses, be able to have considerably larger area of bad paving replaced each year.

As the places where natural asphalt stone, which, when in pulverized form, heated and stamped, reassumes a solid form, is found on our globe seem to be very few, human ingenuity has been exercised by artificial means to increase the supply; and here in Germany, as well as elsewhere, such attempts have been made. In reply to frequent applications for permission to test such artificial asphalts in Berlin, the municipal commission, recognizing its importance not only in a technical and economic way but also in its effects on home industry, has offered some of the public streets of Berlin for such experiments, but naturally at the risk and expense of the parties directly interested.

None of these attempts, though, have produced satisfactory results.

An American company, according to municipal reports, laid a paving in the Landsberger street, which before the end of a year had to be removed and replaced with natural asphalt paving. Also the paving in Köenig street, with artificial stamped asphalt, which was laid in the year 1883 by a German contractor, did not stand the wear nearly so well as natural asphalt pavements, and has already been many times entirely renewed. How satisfactory such paving materials may prove to be in streets where traffic is light has not yet been determined.

Greater durability seems to be possessed by an asphalt pavement recently laid by a German company in Wall street, near its junction with Spittelmarkt. A final judgment, however, can not as yet be given in regard to this any more than in regard to the so-called "caoutchouc-stamped asphalt pavement" tested on the Lüetzorr Ufer.

Wood pavements.—If asphalt, however—so far as natural asphalt is concerned—has shown a satisfactory degree of durability as compared with stone, the same can not be said of wood.

In the municipal reports for the years 1877 to 1881 information was given in regard to wooden block pavements laid in the years 1879 and 1881. In the following years until 1883 other trials were made with this material, especially in the squares before the Armory Museum and the Royal Opera House. For the former American cypress wood was used, and for the latter Swedish pine.

In the year 1884–'85 the area of such wooden pavements in the city of Berlin was about 42,480 square metres. Already in 1883 the wooden pavement laid in 1879 in Oberwall street had become so much damaged that half of it had to be relaid, the other half being renewed in the following year. The wooden pavement laid in the same year (1879) in the street east of the Royal Opera House was in such a rotten condition in 1884 that the street commission was compelled to remove the completely rotted and useless wooden blocks and to replace it with stamped asphalt. In the same way the pavement on Friedrich's bridge, and on Friedrich street between lot 103 and Behren street, after respectively 7 and 6 years' use, had to be completely renewed.

This experience shows why the municipal commission, while not exactly hostile to the extension of wooden pavements, still prefers to wait. It has, however, permitted the Great Berlin Street Car Company, which desired it in the interest of its horses, in streets which are otherwise paved with asphalt, to pave the area within and between the rails with wood. Here also results have been unsatisfactory, and, instead of wood of the pine family, impregnated beech wood has been tried. The first experiments of this kind were in the year 1886–'87 at the Müellen Damm, in Louisen and New William streets. Under these circumstances the area of wood pavements has not materially increased since 1884. On April 1, 1889, as above shown, it amounted to 62,336 square metres. For keeping nearly half of this area in repair the Great Berlin Horse Car Company is responsible.

The experiments in the use of beech wood are as yet incomplete, though it appears that in frosty and snowy weather such pavements are more slippery than any other.

Iron pavements.—The iron paving, which was laid in the year 1877 for a short distance on "Unter den Linden" by the King's and Laura smelting houses, was removed at the request of the experimenters very recently. In continuance of their experiment, however, they were permitted in 1887, at their own risk and cost, to lay a steel pavement on Lange street where it crosses the Wood Market and Marcus street. This steel pavement is composed of wooden impregnated blocks, in the form of paving stones, which, on their upper surface, are capped with steel. These blocks are laid upon a concrete under-bedding, and the seams are filled with a bituminous mass. This pavement, however, has not yet gotten beyond the experimental stage.

Area and cost of pavements.—Concerning the street areas, which at the close of the period covered by this report (April 1, 1889), were paved with asphalt, with wood, and with stone of different sorts, as well as concerning the areas to be kept in repair by the city, by street-car companies (in consequence of contracts to that effect), and by contractors (in consequence of the guaranty required of them—for stone pave-

ments 3 years, for asphalt pavements 4 years), the following table gives information. On the first of April, 1889, there were in existence:

Description.	Kept by city.	Kept by contractors, street car companies, and private persons.	Total.
	Sq. metres.	*Sq. metres.*	*Sq. metres.*
Good pavement:			
Asphalt	260, 000	313, 919	573, 919
Wood	32, 761	30, 575	63, 336
Stone:			
Class I, on broken stone sub-bedding	193, 844	106, 273	300, 117
Classes II and III:			
Broken stone sub-bedding	258, 103	139, 920	398, 023
Gravel sub-bedding	562, 694	184, 513	747, 207
Total area good pavement	1, 307, 402	775, 200	2, 082, 602
Bad pavement:			
Class IV	176, 639	30, 547	207, 186
Class V	357, 865	95, 641	453, 506
Classes VI and VII	1, 209, 491	71, 292	1, 280, 783
Classes VIII and IX	660, 116	17, 343	677, 459
Total area bad pavement	2, 404, 111	214, 823	2, 618, 934
Total area of pavement	3, 711, 513	990, 023	4, 701, 536

From this table it appears that of the pavings kept by the city 1,307,000 square metres, or about 35 per cent., are of good quality, while 2,404,000, or about 65 per cent., are of more or less bad stone. It is therefore apparent that the latter, which, with small exception, is at least 15 years old—a larger part being very much older—every year requires more and more repair and renovation. Even, therefore, if only the absolutely necessary repairs are made, the longer its replacement with good paving is deferred, so much the higher from year to year will the necessary outlay for repairs be. To what extent such repairs have been made in the separate years covered by this report, and what expense has thereby accrued to the city, is shown by the following table:

Year.	Street pavement.		Repairs.		Improvement.	Expenses.		
	In general.	To be kept by city.	No.	Area.		Wages, gravel, sand, etc.	Obtaining new stones.	Total.
	Sq. met.	*Sq. met.*		*Sq. met.*	*Per cent.*	*Marks.*	*Marks.*	*Marks.*
1882–'83	4, 158, 000	3, 600, 900	3, 528	515, 200	14. 3	386, 104	253, 092	639, 196
1883–'84	4, 294, 000	3, 548, 400	2, 385	526, 000	14. 8	398, 690	208, 468	607, 158
1884–'85	4, 366, 300	3, 565, 500	2, 162	414, 800	11. 6	392, 519	178, 888	571, 407
1885–'86	4, 396, 800	3, 545, 500	1, 865	389, 800	11. 0	384, 415	194, 061	578, 476
1886–'87	4, 448, 000	3, 728, 900	2, 007	386, 100	10. 4	400, 305	232, 104	632, 409
1887–'88	4, 529, 000	3, 523, 700	2, 107	418, 700	11. 9	439, 072	129, 298	568, 370
1888–'89	4, 599, 600	3, 608, 400	2, 388	409, 600	11. 4	500, 010	236, 714	736, 724

As the outlay represented in the next to the last column was only for new stones in order to obtain the actual money value of repairs in the period 1882–'89, to the sum 4,333,740 marks must be added the value

of old stones used again, 850,616 marks, which gives a total of 5,184,356 marks.*

The cost of repairs per square metre was therefore 1.416 marks exclusive of the value of old stones, and 1.694 marks inclusive of such value. The average cost of repairs on the entire street area was, exclusive of the value of old stones, 17.2 pfennigs, and inclusive of such value 20.7 pfennigs per square metre.

The labor and cost represented by the above table were expended in the interest of street intercourse owing to damages to the paving from traffic and atmospheric influences. But the streets of a modern city serve other public purposes than those of intercourse. Under the streets are the gas-pipe, canalization, pneumatic-tube, telegraph, telephone, electric-light and water-pipe systems. The laying and repairing of these subterranean systems render a frequent breaking of the street pavement necessary.†

Especially upon the better pavements, however, such breaking open has a bad effect, because they affect not only the street surface, but also the sub-bedding of the street.

Every effort has been made to bring the pipe and cable systems away from the streets and under the sidewalks. Yet at every street crossing the paving must be broken, and in most cases the municipal water pipes can not be laid under the sidewalks as they are not permitted to come within 5 metres‡ of the houses and a very large proportion of sidewalks are 4 metres, or less, wide.§

Years.	Work on water system in streets.		Amount of water pipes laid or re-laid.
	Unimportant.	Important.	
	No.	*No.*	*Metres.*
1878–'81	3,862	15,446	22,702
1882–'89	2,931	20,519	27,269

*The city has a small income which somewhat reduces this amount. Persons who open public streets at their own cost are by statute required, during the first 4 years, for the purpose of keeping up repairs, to pay to the city an annual sum of 20 pfennigs per square metre. In the period from 1882–'89 the city's income from this source amounted to 48,447 marks.

†This applies chiefly to such systems as, for unanticipated causes, require extension. This does not apply to the municipal canalization, as the size of this is not influenced by the demands of the public, but by the amount of rainfall to be carried off. Furthermore the laying of this system nearly always precedes the laying of the better street pavement.

The renewal of the pavement broken open for such purposes is naturally not a municipal expense, but such repairs are made by the street commission at the expense of the department for which the work is done.

‡This regulation was adopted to protect from the water, in case of broken pipes, the cellars and foundations of neighboring houses.

§The following table shows how important were the operations of the water commission, on an average, for each year of the periods considered:

In addition to the paving expenses already alluded to, there are others in the city of Berlin which are as large as the entire outlays of many large towns for paving purposes. These expenses arise from widening old streets, the laying of special crossings on principal streets, laying of temporary pavements in the outer zones of the city, etc. Another expense is consequent upon the doing away with deep gutter stones, which is rendered possible by the extension of the general subterranean drainage system. At the beginning of the canalization work the length of these deep gutters in the districts of radial systems I to VII was 490,350 metres.

Of this before the beginning of the period covered by this report, *i. e.*, before April 1, 1882, 185,680 metres was changed to flat curbs.

In the years 1882–'83 to 1888–'89 there was removed—

Deep gutter stones.	Cost.			Value of old stones used.	Total value of the work.
	Wages, etc.	New stone.	Total.		
Metres.	*Marks.*	*Marks.*	*Marks.*	*Marks.*	*Marks.*
274,877	503,132	298,114	801,246	139,333	940,579

Altogether, therefore, 460,557 metres of old gutter stones have been removed.* Hence it appears that the old Berlin gutters have almost entirely disappeared.

Stone pavements: In spite of the growing use of asphalt in recent years, of the entire street area only 12.2 per cent. is asphalt paving, while 86.5 per cent. is stone. Even when only the better paved streets are taken into consideration the ratio remains 27.5 to 69.5.

The experience of former years taught that it was in every way more advantageous not to buy stones for special cases, but to have a large supply on hand. This, however, necessitates large storing places as well as numerous trained employés.

Of such storing places at the end of the period under report three were in use with a total area of 102,000 square metres. To these places, in accordance with the terms of delivery, the ordered stones are brought by the contractors, and, after unsatisfactory stones are refused, are unloaded by employés of the street commission and the amounts entered in the depot stock books. The entire depot business is under the charge of one of the six building inspectors of the street commission. The compensation of the depot bookkeeper, overseer, and workmen—the director is a life-long official, while the others are employed by the day—amounts to about 16,000 marks per annum. The building inspector has the assistance of three members of the street commission, department II, as curators.

* The report of the municipal street-cleaning commission shows that in consequence of the removal of such gutters the amount of water used for cleansing the same has fallen from 512,397 cubic metres to 133,272 cubic metres.

In regard to the total amount of stone delivered during the period under report, the quantities of different sorts of stone, and the total cost, the following table gives information:

Years.	Broken stones, classes I to III.*	Broken and granite stones.		Sill stones for bordering track rails.	Total cost.
		Classes IV and V.	Class VI.		
	Sq. met.	*Sq. met.*	*Cub. met.*	*Metres.*	*Marks.*
1882–'83	57, 033	16, 221	9, 351	39, 316	1, 358, 287
1883–'84	89, 029	27, 533	6, 994	3, 951	1, 651, 360
1884–'85	89, 833	16, 145	5, 429	3, 238	1, 565, 529
1885–'86	116, 226	17, 458	5, 039	1, 805	1, 964, 296
1886–'87	136, 045	8, 243	581	27, 378	2, 105, 930
1887–'88	92, 572	22, 746	2, 000	17, 713	2, 107, 695
1888–'89	114, 038	11, 622	4, 442	17, 406	1, 669, 707
Total in 7 years	694, 776	119, 968	†33, 836	110, 807	12, 422, 804
		255,312 sq. met.			

* The stones designated as classes I, II, and III are broken stones worked on all their sides into cubic or prismatic forms. Only these are used for distinct paving or repaving. The stones of classes IV and V are erratic blocks with worked square tops, while class VI represents stones broken in polygonal form. These last three sorts are used only for repairing old pavings made of similar stones.

† It is calculated that with every cubic metre of stone of class VI 4 square meters of paving can be laid.

From the above figures it appears that, leaving out of consideration the stone sills which are used for bordering street car track rails in asphalt streets, 73 per cent. of the stones obtained were for the best class of paving, classes I to III; while the rest, 27 per cent., were for repairing old pavings so far as the old stones could not be reused. It is the desire of the street commission to restrict as far as possible the purchase of these inferior stones (classes IV to VI) and to purchase the better sorts with the money thus saved.

The following table shows the origin of these stones. The stones from Norway and Sweden are exclusively granite, while the Belgian stones come from the porphyry quarries of Quenast, near Brussels. The Bavarian and Silesian stones are granite, while those from Saxony are porphyry, greenstone, and granite. The stones from Mark Brandenburg (classes V and VI) are exclusively produced from so called granite erratic blocks.

Year.	From—						Total.
	Sweden and Norway.	Belgium.	Bavaria.	Saxony and Silesia.	Mark Brandenburg.	Other countries.*	
	Sq. met.	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Sq. met.*	*Sq. met.*
1882–'83	44, 994	9, 453	982	13, 132	42, 097	....	110, 652
1883–'84	83, 862	11, 797	....	8, 705	39, 573	365	144. 308
1884–'85	67, 927	26, 219	....	7, 717	25, 731	....	127, 594
1885–'86	75, 367	41, 360	....	9, 839	27, 243	67	153, 817
1886–'87	71, 404	52, 674	1, 464	13, 499	7, 095	476	146, 612
1887–'88	81, 590	536	1, 004	14, 475	25, 713	....	123, 318
1888–'89	80, 485	32, 177	618	1, 136	24, 912	....	144, 328
Total	505, 624	174, 216	4, 068	73, 503	192, 364	908	950, 629
Percentage of the total sum, not including Brandenburg stone	66. 67	22. 90	0. 53	9. 69	....	0. 12	758, 265

* Bohemia and the Rhine province.

The foregoing table shows that the vast majority of the stones come from abroad. Many futile attempts have been made to secure the stones in Germany, but so far the foreign competition has been irresistible. These attempts, however, have assisted the city treasury, as they have caused a fall of prices, as is shown in the following table:

Sort of stone.			Price per 1,000 with cubes, per square metre with prisms—	
Class.	Form.	Height.	Before the year 1885.	Up to April 1, 1889.
		Centimetres.	*Marks.*	*Marks.*
I	Cubes	19 to 20	795	700
	Prisms	19 to 20	18.75	17
	...do	15 to 16	17.75 to 16.0	13.74
II	Cubes	19 to 20	493	480
	...do	15 to 16	370	....
	Prisms	19 to 20	13.10	11.74
	...do	15 to 16	14.60 to 12.75	10.64
III	Cubes	19 to 20	478 to 450	454
	Prisms	19 to 20	12.85	10.74
	...do	15 to 16	13.80 to 13.30	10.00

The total amount of good stones taken from old pavements during the period under report was 270,676 cubic metres. Of this amount 75,091 cubic metres were used again. The remainder was broken up and used as sub-bedding for stone pavements of classes I to III, and for other purposes. A part was sold to neighboring rural communities. As the demand therefor has been lively, the prices per cubic metre have risen from 4 marks to 7 marks and upwards.* The amount of stones thus sold was 49,761 cubic metres, and the receipts from this source were 253,793 marks.

Highroads.—In addition to the streets to which up to this point this report has been confined, there are also within a small part of the city limits highroads; and in addition to these, the city is also responsible for certain country roads built by it beyond the city limits. The reports for the years 1877–'81 show the length of such highroads to have been 70,600 metres. At the close of the period now under report, it had been reduced to 68,150 metres. This reduction is mainly due to the extension of paved streets. As rapid as possible reduction of this amount is desirable, as in warm weather such highroads are exceedingly dusty, and in wet weather they become dirty and slippery; and, furthermore, they are exceedingly expensive to keep in order.†

*In the year 1889 as much as 9.5 marks per cubic metre was offered and paid.

†While, as has already been shown, this cost for paved streets is 17.2 or 22.7 pfennige per square metre per annum, 10 years' observation has shown that the minimum average annual cost for keeping in order such chaussées was 22 pfennige. This cost (22 pfennige) was for the comparatively little used chaussée connecting the Charlottenburg road with the royal porcelain factory.

Name.	Cost per square metre per year, from 1877 to 1888.		
	Highest.	Lowest.	Average for 10 years.
	Marks.	*Marks.*	*Marks.*
Chaussées in the Thiergarten Park:			
Charlottenburg chaussées	1.72	.22	1.23
Lenné street	4.57	.67	1.72
Thiergarten street	2.25	.50	1.09
Spree way	3.04	.36	1.82
Sieges allée	1.77	.29	.77
Bellevue allée	2.68	.05	.56
Grosser way	2.59	.04	.56
Chaussées connecting the city with suburbs:			
Preulauer allée	1.76	.36	.86
Landsberger allee	3.40	.23	.97
Frankfurter allée	1.65	.24	.71
Reinickendoyer chaussée	1.27	.27	.67
Schönbauser allée	1.22	.32	.88

A further reduction of the extent of such chaussées, for whose preservation the city is responsible, will shortly result from an agreement made with the municipality of Charlottenburg. By this agreement Charlottenburg assumes proprietorship and charge of the chaussées on Salzufer and Charlottenburger Ufer, on condition of the city of Berlin paying to it the sum of 9,400 marks per annum. By this agreement is removed a disagreeable condition of affairs under which one city owned and was responsible for a street within the limits of another city.

Sidewalks.—So far this report has been confined to the streets of Berlin. In conclusion it may be of interest to say a few words in regard to sidewalks.

Long before the repaving of the streets began, the movement to replace the old sidewalks was inaugurated. This work was begun soon after the year 1830 by laying granite slabs in the middle of the sidewalks. The next improvement was the covering of those parts of the pavement on both sides of the granite slabs with mosaic-stone plates. Later on, house-owners were permitted to pave their entire sidewalks with asphalt.

A regulation on this subject was issued in 1873 which also gave assistance to land-owners from the city treasury. If one observes, everywhere where sidewalks border on impervious street surfaces, between the granite slabs or asphalt pavement and the curbstone, sometimes a half, sometimes a whole metre of mosaic strips, the reason therefor lies in this regulation. They have a double purpose: First, because if both street surface and sidewalk are impervious the danger arises that gas or water escaping from pipes under the streets, unable to escape upwards, must force its way sidewards into the cellars or under the foundations of neighboring houses. Second, because where it is intended to plant trees on the sidewalks their growth would be impossible with an unbroken street surface.

In accordance with the provisions of the order of the royal police presidency of January 17, 1883, and of the magistracy of February 6, 1874, during the period under report private land-owners laid 186,800

square metres of good sidewalk, and the assistance rendered in this direction by the city treasury amounted to 471,415 marks.

In addition to this, sidewalks were laid by the city in public squares, parks, and along water courses, to an extent of 126,357 square metres, at a cost of 513,722 marks.

W. H. EDWARDS,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Berlin, March 4, 1891.

FRANKFORT-ON-THE-MAIN.

REPORT BY CONSUL-GENERAL MASON.

The subject embraced by the inquiry prescribed in the Department circular of November 8 divides itself naturally, here as elsewhere, into two distinct topics, viz, paved streets in cities and towns, in which various systems of stone, wood, and asphalt pavements have been used with greater or less success; and (2) country highways, which in Germany are uniformly macadamized roads of varying width according to location and the quantity of travel and traffic to be accommodated.

MUNICIPAL STREET CONSTRUCTION.

In respect to sewerage, gas and water service and street pavements, Frankfort presents a complete and interesting example of a well-built and carefully kept modern municipality grafted on the somewhat rude and irregular stock of a mediæval walled city, laid out and constructed upon the ancient model, under which the principal consideration was the accommodation of the largest population within the limited space inclosed by its defensive walls. Down to the beginning of the present century Frankfort was a labyrinth of narrow, tortuous streets, opening at their intersections into small open spaces of irregular form and flanked by buildings five or six stories in height, which for greater economy of space often overhung by several feet the narrow pavement below. These streets were paved with small, round cobblestones, laid upon the natural but well-trodden gravel, and with such profile as to form open gutters at the sides of the wider streets or along the middle of the narrower ones. From 1801 to 1806 the outer walls were removed, the moat filled up, and the space thus acquired was converted into parks, which with the adjacent boulevards encircle three sides of the old town (the fourth being flanked by the river Main) and which now form one of the most attractive features of the city. From that period down to 1867 the pavements were exposed to all the exigencies of sewer-building, gas and water pipe laying, and made therefore little or no progress in quality or change in character.

In 1867 the principal commercial thoroughfares had been provided with gas, water, and sewerage and the construction of solid, well-laid pavements of dressed stone blocks began, subject to the further disturbance which came with the introduction of the first street railway in 1869. Frankfort stands on a level sandy river plain which has a substratum of loose gravel that absorbs water with great facility, and although favorable from a sanitary standpoint, forms an uncertain and treacherous foundation for pavements especially when the original earth has been previously disturbed by the laying of sewers or water-mains. It cost the Frankforters years of experience to learn the all-important lesson that in order to meet the constantly increasing requirements of modern city traffic the essential requisite of a successful pavement is a solid, deep laid, water-tight foundation, and that without this any pavement, however cheap in original cost and fair on the surface, is certain to prove extravagant and disappointing. So well is this principle now established that it is the custom to first grade and lay new streets with a temporary pavement of stone blocks set on the plain gravel and then after some years of use have thoroughly settled and solidified the ground to take up the temporary pavement, excavate to the required depth and lay in a permanent cement and rubble foundation, upon which the original stone blocks, from which soft or imperfect ones are carefully excluded, are then relaid. Frankfort has made careful experiments with macadamized streets and with permanent pavements of three materials, viz: cut stone, asphalt, and wood, and the costs and results in each case will now be separately considered.

Stone pavements.—Stone pavements are usually made of four-sided, wedge-shaped blocks of gray granite, which are obtained at various points, notably from Alsace, from quarries along the Rhine between Mayence and Coblenz, from Passau on the Danube, and from the mountains of the Odenwald. Black porphyry from the Bavarian Pfalz and basalt from the Vogelsberg near Hanau are used in slabs or large, broad blocks for paving narrow streets, but on account of their irregular hardness these slabs soon become rough and unsatisfactory, so that granite is now the standard material for roadways and straight curbstones. The method of construction for the best class of granite pavements in old and important streets is as follows:

The old or temporary pavement is first removed and the earth excavated to a depth of 16 inches. The bottom is then covered with a 2-inch layer of broken stone, over which a steam roller is passed to firmly embed this rubble foundation in the earth. If the bottom is of particularly loose and unstable material, or if veins of water render it soft, small, flat stones are selected, set on edge, and hammered firmly into place. Upon this substratum is then laid a bed from 6 to 8 inches deep of concrete made of best Portland cement mixed with sharp, coarse sand. When this has firmly "set" it is covered with an inch of clean, fine sand, which forms an elastic cushion between the solid con-

crete foundation and the pavement. Upon this are then set the granite blocks, 7 inches square at the top, 8 inches in depth, and tapering slightly from top to bottom to form the arch of the street surface. The seams between the blocks are calked with coarse gravel and melted coal tar, which not only helps to render the pavement impervious and thus protect it against the action of frost, but holds the blocks in place and prevents lateral motion. Such a pavement costs from 15 to 16 marks ($3.57 to $3.80) per square metre, a high figure, but the expense of keeping it in repair is next to nothing, and as it lasts indefinitely, it proves, like all good, genuine work, cheapest in the end.

Next in order come the ordinary stone pavements made of granite blocks similar to the preceding, but laid on the natural gravel or sand, which has been previously graded and rolled as hard as possible with a steam roller. For suburban streets or where traffic is light these common pavements serve reasonably well for a series of years, but they invariably become rough, expensive to clean and maintain, and in the end unsatisfactory. The comparative cost of the two foregoing classes of cut-stone pavements—that is, the best and the ordinary grade—with their respective expense of maintenance during the first 5 years, are shown by the following table, in which the calculation is made per running metre for half the width of the street between curbstones:

Cost of front metre for half of street width.

	Ordinary block stone pavement laid in sand.				Granite block, cement and rubble foundation.			
Width of street.	Construction.	Maintenance 5 years.	Total.	Equivalent per square metre.	Construction.	Maintenance 5 years.	Total.	Equivalent per square metre.
35 feet	$10.58	$1.19	$11.77	$2.11	$18.91	$1.19	$20.10	$3.78
45 feet	12.86	1.52	14.38	2.03	22.61	1.50	24.11	3.47
50 feet	14.28	1.69	15.97	2.00	24.99	1.66	26.65	3.51
70 feet	19.14	2.38	21.52	1.91	34.03	2.38	36.41	3.40

These statistics are somewhat complicated, and from an American standpoint may seem awkward, but they show the German method of keeping accounts for street construction and maintenance. It will be noted that the cost of keeping the two kinds of pavement in repair does not differ much during the first five years, but after that period the superior economy of the better grade becomes more and more manifest.

Of the macadamized streets in Frankfort there is not much to be said. This system was used extensively some years ago, particularly on the broad highways leading into the city, as well as on the circular boulevard which was constructed when the *enciente* was removed in 1806. There is found in this region a dark-colored slaty kind of limestone, which breaks easily and packs firmly on roads of this character. Macadamizing costs when well done about $2 per square meter, but it is the most expensive of all pavements to keep clean and in repair, requiring constant patching and filling to maintain a good surface. It is also

more or less pasty in wet weather, and loses rapidly from the process of street cleaning; it is dusty in dry weather unless constantly watered, and is, on the whole, better suited to country or suburban roads than city streets.

Asphalt pavements.—Of asphalt pavements it can be said that except for sidewalks they have been used only experimentally in Frankfort. The first pavement of this kind was laid down in 1880. Although such as have been laid have stood the test of use reasonably well, they have been subject to the usual objection of being dangerously slippery in muddy weather. Here, as elsewhere, it has been found especially requisite that asphalt pavements should be kept clean, and this is possible without great expense only where the same kind of pavement is laid continuously over large street areas and the margins where asphalt pavements are entered upon from macadamized or gravel roads kept free from mud by constant cleaning. Otherwise country wagons soon cover them with dirt which in wet weather makes the asphalt a slippery and treacherous footing. Experiments were made some years ago with a native asphalt from Sisal in Hanover, but it was of inferior quality, and has been replaced by the French material from Val-de-Travers and by asphalt from Sicily. Good asphalt pavement requires a firm rubble and cement foundation, and when well and thoroughly done after the process which has been so long and successfully used at Paris, costs in Frankfort from $3.30 to $3.50 per square metre, or nearly as much as the best kind of stone pavement, to which it is inferior in point of durability and expense of maintenance.

Wood pavements.—The experiments with wood pavements began at Frankfort in 1885, when a part of the "Zeil"—the principal business thoroughfare of the city—was paved with that material. Subsequently, a part of a much traveled street called the "Steinweg" was set apart for further experiment. Contracts were given to five different firms, who laid down their special varieties of wood pavement, in which were used German beech and pine, Swedish pine, American cypress and yellow pine, part of which were impregnated by different methods and part not impregnated at all. All these several wood pavements were laid in the most careful and thorough manner upon impermeable cement and rubble foundations, similar to those employed with the best class of granite pavements, and they are all in good condition to-day after more than 5 years of severe and constant use. As to which of the five varieties has proved superior, I can give only the opinion of Mr. W. H. Lindley, chief engineer of this city, who declares in favor of the Kerr system, an English method which has been employed on a large scale during recent years at London and Paris. The Kerr pavements laid down in Frankfort are made of blocks of Swedish pine 4 inches in depth, not impregnated, but set in a salve of melted coal-tar upon the orthodox cement foundation 8 inches thick, and which rests on 2 inches of broken stone. It is well known that the municipality of Paris has

adopted the Kerr wood pavement for some of its most important streets and avenues, under an arrangement by which the patentee lays down the pavements at his own expense and keeps them in good repair for a yearly rental of 2.50 francs (47½ cents) per square metre, a rate that would be considered extravagant in most European municipalities.

There appears, so far as can be ascertained, nothing mysterious or extraordinary in any of the wooden pavements which have been tried with such uniform success in Frankfort. The important fact is that they are all well and honestly constructed. Whether impregnation of the blocks is of any important advantage in this climate is an open question, but the three essential requisites are carefully observed, viz: 1, a solid, impervious, concrete foundation; 2, blocks of sound, well seasoned wood, carefully selected, and free from spongy, sap-rotted, or otherwise imperfect pieces; 3, each block firmly set in hot pitch, and the interstices poured full of the same material. There is no laying of wood pavements here upon pine boards resting on sand or gravel, with the frost lifting them out of place each winter and the water oozing up through them from every surface vein or leaking water main. Such experiments have been left exclusively to the more courageous municipalities of newer and less conservative countries.

Sidewalks.—Sidewalks were made in early times of cobblestones set in sand, then small squared granite blocks were used; next asphalt was extensively employed, but since 1876 the principal sidewalks in Frankfort have been built of concrete in the following manner: When the grading is finished and rolled to uniform hardness and solidity there is laid down a bed 5 inches thick of concrete, composed of one part of Portland cement and seven parts of coarse gravel. Upon this is then spread a surface coat 1 inch thick of concrete, containing equal parts of cement and fine clean sand. While the surface is still smooth and soft it is cross-hatched with shallow lines into rectangular or diamond-shaped squares, which give a finished appearance and offer a more secure footing in wet or wintry weather. Curbstones are of granite, with syenite blocks for curves and street corners.

COST OF THE VARIOUS PROCESSES.

From the last report of the city engineer of Frankford there is herewith translated the average cost per square metre of each process involved in constructing the various kinds of pavements and sidewalks, viz:

1. Smoothing and preparing surface, grading not included	\$0.05 to \$0.16
Sidewalks:	
2. Steinheim granite blocks in rows	1.19
3. Pfalz granite blocks in rows	1.55
4. Steinheim granite slabs	1.66
5. Concrete, per process above described	.95
6. Of molten asphalt spread over broken stone	1.15
7. Asphalt slabs from Val de Travers	1.90
8. Macadamized	.71

Street roadway:

9. Of cobble stone, top dressed, on sand bed	$1.75
10. Square blocks Pfalz porphyry on sand bed	2.24
11. Square blocks hard basalt on sand bed	2.85
12. Square blocks Alsatian granite on concrete foundation	$3.90 to 4.40
13. Square blocks Vilshofen granite on concrete foundation	4.65
14. Molten asphalt on concrete foundation	3.70
15. Natural French asphalt on concrete foundation	4.65
16. Wood pavement, beech or pine	4.15 to 4.85
17. Curbstones of syenite, including setting on cement foundation, per linear metre:	
Straight	1.90
Curved	2.00

In the above items, from No. 12 to 16, inclusive, there is included 85 cents per square metre as the cost of the concrete and the rubble foundation, which, as already explained, is an essential part of all high-class roadway pavements in this city.

The expense of pavement construction is provided as follows: For repaving old streets within the city the whole cost is paid by the municipal treasury from the public fund. New streets in the suburbs are first paved at public expense, but when the adjacent property is afterwards built upon the city assesses upon the owners of such buildings the full cost of the paving in front of their land up to half the width of a street not more than 26 metres wide, the excess above that width remains to be borne by the public treasury. Finally, and this is a point which American municipalities should not lose sight of, permission is never given to private parties to cut the pavement through a street for any purpose. When such work is required the party desiring it applies to the proper bureau, the work is done carefully and thoroughly by the city authorities, and the party who has made the petition pays for it.

COUNTRY ROADS.

The excellent roads of Germany are mainly a heritage from the century which immediately preceded the introduction of railroads. In those days the mails and the few travelers who journeyed by public conveyance were carried by post chaises; freight was transported by great lumbering wagons, each drawn by six horses, and what was regarded as not less important in that period of prolonged and incessant warfare, broad, smooth roads were necessary for the rapid movement of the king's armies with their supply trains and artillery. Accordingly the construction and maintenance of public highways was then an important function of the national government, administered by a vast bureau or department similar to the department of Ponts et Chaussées now maintained in France. It required many years after the introduction of railroads to persuade the conservative officials of the Prussian Government that the period of freight wagons and post chaises was forever past, and that thenceforth their splendid system of

macadamized and graded highways must play a secondary rôle. The lesson was finally learned, however, and on the organization of the empire in 1870, or soon thereafter, the state assumed control of the principal railways and turned the public roads back to the care of the provinces. The consequence is that Baden, Wurtemburg, Bavaria, Westphalia, and the other provinces of Germany have each their separate system of administration for the construction and maintenence of public roads. This administrative machinery is based upon a political system so different from our own as to nearly or quite deprive it of all practical interest in this connection; but in respect to methods of construction the results of German experience may furnish some timely suggestions.

As a result of the circumstances already noticed very few new roads are now constructed in this part of Germany. The great national roads which were built before the railway period are adequate for all military purposes. The principal work of later years has been to improve suburban highways and secure easy communication at all seasons between important railway stations and the surrounding districts. For this purpose narrower and cheaper roads than those formerly built are frequently adequate, so that it may be said in general that the standard of road building has deteriorated during the last 20 years in all parts of Germany, except Baden, where the highest grade of excellence is still maintained. In respect to construction, the German process is identical with that of France and Switzerland. Every important road is a graded, macadamized turnpike, with culverts of massive stone, ditches on either side (which are paved wherever there is danger of washing) and generally lined with trees (either poplar, sycamore, or linden). All slopes and counterscarps are secured by grass, planted from seed when the soil is sufficiently fertile to receive it, otherwise by turfing. Where the slope is necessarily steep and unstable, it is faced like the retaining walls of embankments, with solid masonry.

The profile and alignment of each road is a skillful compromise between directness of route and an easy gradient. Wherever practicable, the road is a straight line between the points connected; when the exigencies of surface forbid this, the best skill of the engineer is employed to circumvent the obstacle by the most direct route compatible with a practicable grade. Bridges were formerly exclusively of masonry, but of late years iron and steel structures of various patterns similar to those used in the United States for railway and road bridges have been introduced. Wherever a German road is flanked by a slope or precipice which presents the slightest danger, the exposed side is guarded by a line of heavy stone posts, connected wherever necessary by railings of iron or wood, and in many places these pillars are of white basalt, which renders them more easily distinguishable at night. There is, apparently, no rigidly prescribed limit to the gradient of German roads. They are classed according to width, which varies from 7 to 8½ metres—that is

from 22.9 to 26.47 feet. The line and gradients having been established by survey, bridges and culverts constructed, and the whole surface of the roadway graded to a flat uniform surface of the required width, and all filled portions rolled and thoroughly settled, the wagon track, which is from 4 to 5 metres wide, is first spread with a 2-inch layer of broken stone which is crushed by heavy rollers into a firm and even foundation. If the ground should prove treacherous by reason of springs or quicksand, larger stones are chosen, set upon edge and rammed into place until a secure foundation is obtained. Upon this layers of broken stone are added, rammed and rolled to a depth of 21 centimetres (8½ inches). The wear of daily travel and traffic does the rest.

The cost of such a road depends naturally upon several conditions more or less variable, such as the nature of the ground and consequent expense of grading, the distances to which stone, earth, etc., must be transported, and other circumstances. The only method of reaching an approximate estimate is therefore to analyze the construction account of certain roads which have been built in Germany during the past 30 years.

For this purpose we select as an example of a first-class highway of the broadest type, one which was built about 10 years ago over a level expanse between the villages of Langenfeld and Burgwald. The road in question is 2,100 metres (2,324 yards) long and 26½ feet in width, the macadamized wagon track being 13½ feet wide and 8½ inches thick. With labor estimated throughout at 36 cents per day, except for stone masonry which costs in country districts from 60 to 75 cents per day, the construction account of the Langenfeld and Burgwald Chaussée foots up as follows:

Grading roadway	$707.61
Planting and turfing slopes	89.96
Bridges and culverts	154.70
Macadamizing	3,647.35
Markstones, numbers, etc	11.38
Tools	75.68
Damage to adjacent property during work	155.65
Tree planting	61.88
Superintendence of construction	369.85
Incidentals	49.98
Total for 2,100 metres	5,324.24

This is equivalent to about $3,646 per mile.

The above exhibit represents the average cost of converting an ordinary dirt road in a country district into a macadamized chaussée of maximum width and standard quality. From a report published at Guben in 1883, by State Engineer Schultze, the following statistics are copied which show the net cost per running metre of several important

roads which were built under supervision of the author during the period from 1871 to 1882:

Designation.	Length.	Width.		Cost.		
		Whole road.	Carriage way.	Total.	Per running metre.	Equivalent in dollars per mile.
	Metres.	*Metres.*	*Metres.*	*Marks.*	*Mks. pfs.*	
Beeskow Lieberose	20, 036	8. 79	4. 39	138, 823	6 93	$2, 630
Lubben Lieberose	32, 500	8. 79	4. 39	275, 646	8 48	3, 224
Friedland Weichensdorf	6, 546	9. 00	3. 75	48, 727	7 47	2, 838
Ziebingen Furstenberg	13, 533	8. 50	4. 00	115, 241	9 67	3, 689
Zweinert Goetz	17, 680	8. 50	4. 00	126, 113	7 13	2, 710
Liebrose-Peitz	6, 177	8. 79	3. 75	59, 668	9 66	3, 689

In respect to the expense of maintaining well-built roads in this country it is difficult to obtain statistics which prove any definite result. Once built, the cost of keeping a chaussée in repair is in proportion to the weight of traffic which it carries, modified somewhat by the varying quantity of heavy, washing rains which fall and in some cases, notwithstanding all precautions, choke culverts and overflow and damage the roadways. But these accidents are rare and generally trivial, so that the work of keeping a German road in repair consists mainly in replacing with broken stone the material which is ground up by travel and washed off as mud, or blown away as dust.

FRANK H. MASON,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Frankfort-on-the-Main, February 13, 1891.

HAMBURG.

The streets of Hamburg are at present in such a wretched condition that I would not like to recommend any system they use here for any city in the United States.

The press of this city are full of complaints about the paving of streets and the bad condition of the highways. A movement is, however, on foot to secure better streets for the city, and I shall report upon any progress made here in this direction.

CHAS. F. JOHNSON,
Consul.

UNITED STATES CONSULATE,
Hamburg, December 31, 1890.

MAGDEBURG.

REPORT BY COMMERCIAL AGENT WASHBURN, OF MAGDEBURG.

CITY STREETS.

Magdeburg has a population of 180,000. Its streets—city proper and suburbs—are uniformly paved with stone. The particular grade is a kind of porphyry, which is unusually hard and has the advantage of being quarried in the immediate vicinity. In the work of paving two classifications are made:

The first is known as the reihen pflaster (pavement in rows). The stones used for this purpose are required to be of uniform size and of the following dimensions: 7½ inches long, 5½ inches broad, and 7 inches deep. The spaces between the stones are filled with sand. This is the usual pavement in the principal streets. The cost is estimated at $3.425 per square yard.

In those streets where the traffic is exceptionally heavy the foundation is a mixture of gravel, cement, and chalk. Tar is used to fill up the spaces between the stones. Further, the pavement is doubled. This has been found to be especially advisable in the narrow streets, where the wear and tear are necessarily greater.

Streets of the second class are paved with kopfstein pflaster (headstone pavement). The stones called for are of various sizes and dimensions, as broken in the quarry. The method of paving is the same as in the first class. The less important streets are paved in this manner, though it occasionionally happens that some of the principal streets are so paved temporarily. The cost of this construction is about $2.40 per square yard.

All work is done by contract. The original pavements of both classes are always torn up at the end of 2 or 3 years and repaved permanently. This is to correct the unevenness due to settling. The same materials are used and the cost is slight. Experience has shown that, with occasional repairs, streets so relaid last a quarter of a century or more.

COUNTRY ROADS OR HIGHWAYS.

The country roads in this vicinity are always more or less elevated. They are constructed of such material as is nearest at hand and most available. A slight excavation is made where the road is to be built. This cut is filled with gravel, and water sprinkled upon the gravel. Then follows a layer of small pieces of broken stone and gravel and water. This is made compact by repeated rolling. Generally there is a second layer. These roads have all the smoothness and hardness characteristic of the continental highways. It is impossible to give any constant estimate of their cost, for the reason that this largely depends upon the cost of transportation of the material.

Country roads are built or repaired by order of the kreisdirection—a local assembly whose members are elected for definite terms. The official immediately in charge of the roads is the kreisbaumeister. This officer is selected only after special training for the work, and is appointed for life. He generally has several assistants. Reports on the condition of the roads are made from time to time, and the recommendations they contain are usually followed by the local board. It frequently happens that large property owners desiring a road through or near their possessions are called upon to defray the expenses of construction by a special tax. In some of the more sparsely settled districts the roads are built directly by the general government.

ALBERT H. WASHBURN,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Magdeburg, January 16, 1890.

PLAUEN, SAXONY.

REPORT BY COMMERCIAL AGENT PETERS.

CITY STREETS.

In the construction of the streets and roads of Plauen, Saxony, one will note two modes, namely, the temporarily constructed streets—streets made for the time being, and the finally constructed streets—streets constructed with a view to leaving them as first put down.

Of late the temporarily made streets are laid at such a depth that they form a foundation for the finally made streets, so that the latter, whether macadamized or paved, may be erected on this foundation.

By the various ways and systems of making roads the lowest section always consists of 10 centimetres of coarse gravel or small broken stone and 15 centimetres of gravel packing.

Construction.—For the foundation of the roads small broken stone and gravel-packing (bottoming) is being used, which is found in the quarries surrounding Plauen.

Macadamizing is done for light traffic with lydian stone (siliceous schist) or foundation stone (grundsteinklarschlag) found in the neighboring quarries, and for heavy traffic with basalt from Waldsassen.

The paving of the finally built roads is done with split granite or syenite, which is furnished by the quarries of Grimma, Schneeberg, and Kirchberg, all three towns of Saxony, as also of Schönbrunn, in Bavaria. The sidewalks, which are temporarily built, are made of gravel and are framed with herborized (slate-clay) slabs, which latter come from Theuma near Plauen. The final building of the sidewalks is done with cement granite or burnt clay slabs, manufactured in the establishments of Fickentzscher of Zwickau, Saxony, and of Meisel of Muldenstein, near Bitterfeld.

The granite slabs for framing these sidewalks are purchased in Kirchenlamitz, Bavaria.

Cost of construction per square metre.—Temporary macadamization with lydian stone including the foundation, but exclusive of earthwork, as digging, etc., 2.50 to 2.80 marks; final macadamization with lydian stone including the foundation, but exclusive of earthwork, as digging etc., 3.20 to 3.60 marks; final macadamization with basalt 4.20 marks; paving with finished blocks, including foundation, 12.50 marks; gravel sidewalks, 0.50 marks, and footpaths with granite slabs, 7.50 marks.

Cost of maintenance per square metre.—The macadamized streets of the city (for one year) for light traffic, 0.50 to 0.60 marks; for medium traffic, 0.80 to 1.20 marks; for heavy traffic, 1.20 to 2.30 marks. Of the so-called communication ways (macadamized); for light traffic and with exposure to the sun, .05 to .08 pfennig; for light traffic without exposure to the sun, .07 to 11 pfennig; for heavy traffic without exposure to the sun, 15 to 20 pfennig.

In stating above costs of maintaining the roads, the expenses incurred by the planting of the trees and the cost of plain footpaths or ditches are not included.

An actual count of road traffic has never taken place here.

The cost of materials delivered at the place where the material is needed is as follows, per cubic metre: Lydian stone (kieselschieferklarschlag), 7.35 to 7.50 marks; basalt (basaltklarschlag), 12.7 marks; finished paving stones, 7.50 marks; bricks for paving (klinkerplatten), 4.50 marks; granite slabs for framing per running metre, 6.50 marks; slate-clay slabs (fruchtschieferplatten), per running metre, 0.50 marks; gravel packing, 2.50 marks; broken stones, 1.80 marks; gravel, 1.50 to 3.40 marks; according to the distance between the gravel mine and the place where the material is used.

No information can be had here as regards the price of the material before it is made ready for use.

The Government has no especial control over the streets of towns, nor does the Government pay anything towards maintaining them.

COUNTRY ROADS.

Roads and streets beyond the town limits are partly Government roads (Staats-Strassen) partly country roads (Land-Strassen); the former are built by the state, the latter by the villages deriving the benefit of said country roads.

The cost of building the new streets is borne almost entirely by the parties owning and improving the surrounding property; naturally the value of the property affected is increased, but varies according to location.

In many instances property has increased ten and fifteen fold within a few years.

THOMAS W. PETERS,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Plauen, January 29, 1891.

SAXONY.

REPORT BY CONSUL MERRITT, CHEMNITZ.

CONTROLLING SAXON ROADS.

Preliminary, and inasmuch as the subject is one controlled entirely by the "executive" branch of government, it may be deemed advisable to describe the manner of controlling Saxon roads.

The king possesses sole executive power in Saxony. Saxony is a limited monarchy, with an area of 5,776 square miles. Its population is 3,270,579, which shows that, with the exception of Belgium, Saxony is the most densely populated state in the world.

There are four principal divisions or departments of the kingdom. These are called "kreishauptmannschaften," with headquarters as follows: Dresden, Leipzig, Zwickau, and Bautzen. At each city named is an officer called a "kreishauptmann." He is the representative of the king and the department of the interior. He is the chief executive and ministerial officer of his district or department. His powers in some respects are superior to those of a governor of a State in the United States, but his duties are not altogether similar, or, indeed, definable in such a report as this.

Subordinate to the four chief executive representatives of the king, as above related, are twenty-seven important executive officers distributed throughout the kingdom in subdistricts called "Amtshauptmannschaften. Such an officer is called an "Amtshauptmann," and his functions are like those of a "kreishauptmann," but limited to his own district.

The skill, energy, and thorough education, as well as qualification and executive ability of these 27 men is the cause of the splendid government and fine condition of the road system of Saxony. It is without doubt the finest system of roads in the world and is the result of patient toil, extensive experiment, and disciplined attention. Very early in the history of Saxony it appears that the rulers were actively alive to the principles embodied in the next following remarks which constitute this report:

HISTORICAL ROAD NOTES.

A road system is one of the means of facilitating trade and intercourse. The creation of the former is therefore intimately connected with the development of the latter, while the importance and expansion of trade and intercourse are again directly proportionate to the degree of civilization that has been attained. A national or international division of labor would indeed not be possible if existing means of communication did not insure the greatest freedom for the exchange of merchandise and produce, as well as the movement from place to place of individuals.

A systematic and efficient development of the means of intercourse can, of course, be expected only in countries where the chief executive authorities are invested with all the powers necessary for the attainment of this end.

In Germany the beginning of the establishment of a methodical road system is coeval with the development of the principle of recognized sovereignty. During the middle ages effectual progress was much retarded, partly by the lack of unity among the then numerous German States, partly on account of the imperfections of the methods of road-building then in vogue.

The building of turnpikes began to assume great proportions with the beginning of the present century, the first half of which may be justly termed the classic age of the construction of state roads. Government roads were built to connect the various sections of the country with each other and with the adjacent localities of neighboring countries.

Since the introduction and development of railways, the latter have assumed to a greater and greater degree the functions of the road system, as also of the system of canals and other navigable ways. The road system, however, still serves the very important purpose of effecting local intercourse, and of connecting the local freight and passenger traffic with the railway service.

As regards Saxony, the oldest records pertaining to roads deal exclusively with the use and keeping up of certain roads on the part of those interested in commerce and trade, and with prohibiting the use of other roads.

The roads were only occasionally repaired, and then only when their defective condition threatened injury to the interests of the State, or when the complaints as to the impassableness of the road on the part of the traveling public, which was restricted to the use of certain roads, became so emphatic that the equity and necessity became apparent of providing for the people's safety and convenience in return for the tolls they were obliged to pay. The general principle which obtained was that the obligation of keeping up the roads depended on the levying of toll and safeguard * duty on the same, and for that reason the expense of repairing the roads was met principally with the proceeds of the safeguard duty; the coöperation of the cities, the nobles, the parishes, and the owners of realty in keeping up the roads seems always to have been required.

The Saxon princes regarded it as not only their duty to provide for the security of roads on which the safeguard system was not applied,

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* This species of toll was so called because in former times travelers passing over insecure roads leading through forests or thinly settled districts, were escorted by armed knights who levied this safeguard duty in return for their services. However, the duty continued to be collected long after a personal escort had fallen into disuse.

and to superintend those parties on whom by custom or special provision of law the duty of keeping up said roads was incumbent, but also as their prerogative to set aside certain roads for commercial purposes, to levy a duty on the merchandise thereon transported, and, in order to facilitate the collection of this duty, to forbid the trade from making use of any other roads.

The repairing of roads, the keeping up of which was by custom the duty of the State, was done in part by the state roads employés, in part left to those to whom the collection of safeguard duty was farmed out. The necessary timber was taken from the state forests, the hauling and manual labor were performed by the subjects, the necessary money was obtained by the safeguard receipts, or provided by the local state authorities.

However, the condition of the roads, especially during and after the thirty years' war, was far from being satisfactory, and was the subject of repeated popular complaints to the "Landtag" (state legislature).

The orders and instructions issued by the Saxon princes during the seventeenth century first established the rule that the obligation to keep up the roads rested on those who collected safeguard duties thereon, or who were by custom bound to repair. Furthermore, cities were held to keep up the roads within their territory, parishes within their local limits, and where the obligation could be fixed on no other party the repairs were made by the state.

The act of road building was then yet quite simple, and nothing more was aimed at than the construction of a road that would be moderately passable. The obligation of the subjects extended no farther than to the digging of the ditches or gutters, the picking up of fallen timber, the cleaning of the water courses, and the removal of snow from sunken roads.

An order issued about the beginning of the eighteenth century first established the division of roads into main roads and common roads and ways, and provided that the former were to be kept up at the expense of the state; the latter by him on whom the duty devolved by custom.

The width and general nature of the roads were regulated by special provisions; overseers were appointed for the main roads, and commissioners were created with supervisory powers subject to detailed instructions.

It was at this time that gravel, sand, and rock were first substituted for the wood which, in the same manner as American "corduroy" roads, had hitherto been employed in road building, and that orders were given to replace wooden mileposts by substantial milestones, on which the directions and distances of the villages, and especially of the cities, were to be noted. The expenses were to be borne by the respective parishes and by the state for such roads as traversed public lands.

Complaints regarding the defective state of the roads repeated them-

selves with as equally great frequency as did the severe instructions issued to the nobility, the city councils, the parishes, and the subjects, on whom devolved the duty of repairing the roads, to keep their roads and ways in better condition, to clear the ditches, and remove all obstructions, under pain of military execution. During the 7 years' war the roads fell into complete decay, and unusual orders and measures were necessary for the re-establishment of orderly conditions. Thus, for example, to promote and facilitate road building, it was permitted to call out the militia, paying the soldiers a moderate sum, not, however, amounting to the usual day wages.

Road Law of April 28, 1781.

The promulgation of the road law of April 28, 1781, constitutes an important event in the history of road-building in Saxony. The first part of this law treats of the removal of obstructions to road-building; the second, of the ways of carrying on the work of construction; and the third, of the preservation of the roads and of the tools and implements thereunto belonging.

The roads themselves were classed by this law as:

(1) *Military staple and state roads*, or such as had been confirmed by former ordinances and led from one frontier to another, passing through the staple and trading town of Leipzig;

(2) *Interior trade roads*, leading from one trading or market town to another, and serving for lighter freight traffic and for the postal service; and

(3) *Country, town, and local roads*, which served for bringing the products of nature into the cities, and aided in the carrying on of agricultural pursuits.

This law did not affect the obligations of construction and repair heretofore existing. Cities and country parishes continued to be liable for the keeping up of the roads within their respective jurisdictions, outside of which the charge for keeping up the military and state roads devolved either on the state or on him who collected safeguard duties, bridge, and other tolls thereon. The preservation of local and country roads remained the duty of the respective interested parishes.

The direct assistance of the local subjects in repairing such roads as were kept up at state expense was no longer required. Road-building was regarded as a proper concern of the state government, and the principle was established that those on whom the obligation to construct roads was fixed by law were bound to compensate all private land-owners whose land was taken for public road purposes, to the extent of the actual productive value of the land so taken. The proviso was, however, added, that the owner of land adjoining a road must cede the space required for the projected road or the widening of an existing road, without claiming compensation, when the total area thus ceded is less than a certain extent—so much as could be seeded with two pecks of Dresden measure.

The state parliaments annually voted considerable sums for the construction of convenient and durable roads, declaring them to be an essential condition of securing easy intercourse among the people, of facilitating the conveyance of the necessaries of life, of promoting the prosperity of the industries, of trade, and of transportation. It was ordained that the interested parishes should contribute to a reasonable extent not only in the construction of less important roads, but also in that of the main trade roads.

During the course of time the Saxon Government has not only contantly kept its state roads abreast of the latest attainments of engineering art, but has also constructed new roads wherever their need became evident, and where the parishes on account of their financial situation, or for other reasons, could not well be expected to build new roads or ways of such a character as would meet the actual wants of trade.

Present Classification of Roads and Ways.

The old classification of roads into military, staple, and state roads, interior trade roads, and country, town, and local roads gradually lost its significance as the conditions of trade became altered.

The classification which obtains at present is essentially based on the obligation of keeping in repair, and is as follows: (1) State roads (turnpikes); (2) country roads, connecting two or more towns or villages; (3) streets for the accommodation of the interior traffic of cities and towns; (4) private ways.

(1) *State roads.*—All roads that have heretofore been kept up by the state, as well as such roads as have been built by the state either on its own initiative or on the proposition of the interested localities, and which are likewise kept up by the state, are regarded as state roads.

At every session of the "landtag" petitions are received from numerous localities asking for the construction of new roads at state expense. During the last 10 years the rule has gradually been adopted to leave the construction of new roads to the interested localities. As an utmost concession, roads which are to serve primarily for through-trade may be built at state expense, if the parishes benefited thereby furnish the right of way, and, in some instances, obligate themselves to bear a portion of the cost. When finished, the keeping up of these roads becomes a charge on the interested parishes. However, to enable the construction of country roads where greater difficulties have to be overcome than is usually the case with the class of roads kept up at the expense of the parishes and the manors, a certain sum—at present 300,000 marks per annum—voted by the "landtag" for the financial encouragement of road-building is annually distributed by the department of the interior in accordance with the estimates submitted by the proper district authorities.

Some parishes engaged themselves in former times to make regular contributions of money or material on condition of the state's building

a new road, or taking in its charge an existing road, and this obligation remains as about the only case in which parishes are still compelled to contribute to the keeping in repair of state roads. However, a general provision of law requires those parishes that adjoin state roads to furnish the necessary hands for shoveling the snow off the roads and for hauling it away. The state makes a certain allowance for this, which, however, is usually insufficient, so that the parishes must make good the difference out of their own treasuries.

The right of way for new state roads may be condemned by the state on fully indemnifying the respective land-owners. In like manner the owners of land adjacent to proposed roads are obliged to permit the authorities to make use of all such road-building material as may be found on their land, a suitable indemnity being allowed.

Where state roads lead through towns, the state does not undertake the construction of sidewalks, drains, curbstones, and the like, rendered necessary by local conditions.

However, the paving and keeping in repair of the pavement of such portions of the road are at the expense of the state.

The tolls which were formerly collected on the state roads and bridges have been abolished since 1884, partly in view of the satisfactory financial situation of Saxony, partly because of the many inconveniences caused the traveling public, partly also on account of the great expense incident to their collection.

The general supervision and management of the construction of state roads is intrusted to a state road commissioner, the technical direction of the works being in charge of a special officer termed a road director. The local supervision is exercised within the limits of their respective districts by the "Amtshauptmannschaft," which, as before stated, is the chief executive and ministerial office of the district. The direct technical control of the operations, the making of plans and estimates, and the actual construction of roads, are in the hands of "inspectors of roads and navigable ways," whose offices are usually at the seat of the "Amtshauptmannschaft." Every road inspector must have successfully passed the examination for state engineer. When the amount involved does not exceed 600 marks the road inspector may make the estimates, conduct the repairs, or let the contracts himself. For the execution of larger works he must obtain the approval and coöperation of the Amtshauptmannschaft. Road inspectors are aided in their work by assistant road inspectors—usually trained builders—and by a number of state roadmasters. The latter need pass no special examination, and may prove their fitness for the place in some other manner.

The roadmasters are to assist in the preparatory work and in the construction of state roads. They are charged with the immediate direction of the work of keeping the roads of their road district in repair; this not only with reference to the state roads, but also to the country roads, the keeping up of which is at the expense of the vari-

ous localities. When new roads of the latter class are to be built the roadmasters are also charged with the direction of the work. They are assisted by roadguards and by hired day laborers, and are charged with directing and overlooking the work of all persons employed on the roads of their district. They are to give careful attention to maintaining a sufficient number of laborers who are qualified and equipped for road work, and especially to the training of suitable parties for the position of roadguards. Furthermore, they are to exercise due care to insure a strict observance of the road laws on the part of the public, and to keep a watchful eye on their employés in order that the latter may in no wise annoy the public, as for examples by frightening horses.

(2) *Country roads* (*Communicationswege*).—Public roads not state roads are generally termed "connecting" roads in so far as they serve to connect two or more towns.

The road law of January 12, 1870, makes the construction and repair of these roads and of appurtenances such as bridges, ditches, drains, guideposts, etc., the obligation of the parishes through whose territory they lead. In this respect the royal castles, state forests, manors, and other estates not entering into the parish organization are classed as parishes and likewise bound to keep up the roads within their territorial limits, and to construct such new roads as the volume and nature of traffic render necessary.

Passage ways leading from a public road to adjoining parcels of land must be built and kept up by the owners of that land. If, however, the location of a road is changed or a new road established, necessitating a change in the location of the passage way or the construction of a new one, this work thus incidentally occasioned by the parish is to be done by the parish.

When additions are made to the territory of towns or cities, necessitating the construction of new roads, the expense thereof must be borne by the owners of the land forming said additions, the community merely charging itself with the subsequent repairs. The same rule obtains when a change in location of an existing road is rendered necessary by the construction of a railway, the establishment of artificial or the correction of natural water-ways.

Exceptions to the rule that every parish must build and care for the roads within its limits have been generally abolished. They still exist only when founded on special contract, or when coupled with advantages to the obligor, and can be terminated on notice given by either party, full indemnification being made either by the payment of a single lump sum or of a fixed annuity. This applies particularly to the so-called "communities" (Altgemeinden), the original members of which generaly agreed to hold the land in common, dividing the profits among themselves, but undertaking, on the other hand, to keep up the roads of the community without the coöperation of the later arrivals.

When the boundary line between the parishes passes along on a road each parish keeps up that portion falling within its limits; in case of doubt the expenses of repairing is equally divided. If, however, the boundary merely runs along the side of the road, the duty of keeping in repair devolves wholly on the parish having territorial jurisdiction.

Propositions looking to the construction of new roads, or the chang, ing of the location of existing roads, are to emanate from the interested parishes and manors, who likewise are charged with the management of roads and with the immediate direction of the work of construction and repair.

Supervisory powers are exercised by the "Amtshauptmannschaft," which is charged with the infliction of penalties in case the parishes should prove unfaithful to their trust. But, as a rule, the "Amtshauptmannschaft," after a consideration of the complaints that have been lodged, merely ordains the construction of the necessary new roads, or the thorough overhauling of such as are in defective condition. It is also customary for the "Amtshauptmannschaft" to specify every year the road work that appears to be most urgent.

The jurisdiction of every Saxon "Amtshauptmannschaft" is coextensive with the limits of a kind of district formed by a union of parishes and for certain purposes. The district owns some district property, manages such affairs as concern several parishes at once, and provides for matters of a common interest for which the resources of the individual parishes are not sufficient. The district board is charged with the supervision and encouragement of country roads, and usually strives to attain the desired results by assisting the poorer parishes in defraying the expenses of construction and repair with the accumulated increment of the district's property, also by undertaking to keep up certain roads which accommodate the through trade as district roads at the expense of the district; in some cases also by employing a salaried district roadmaster to assist the "amtshauptmannschaft" in the control and supervision of country roads, and to perform, with reference to these, duties similar to those devolving on the state roadmasters with reference to the state roads.

When it is the desire of a parish to discontinue a certain road, that is to withdraw it from public use, the "Amtshauptmannschaft" must be notified and makes public announcement of the intended discontinuance, summoning all parties who might have objections thereto to make them known within a fixed time. At the expiration of this term the "Amtshauptmannschaft," in conjunction with a committee composed of city and parish delegates and the highest tax-payers of the district, decides whether the proposed discontinuance is to be approved as in the interests of the public or whether it is to be rejected.

If a dispute arises as to whether a road is public or private, the question is decided, after due examination, by the "amtshauptmannschaft" and the district committee. A road is considered as public when it

has been in unobstructed public use for at least 30 years. It is presumed to be public when returned by the state land survey as exempt of taxation and entered as a public road on the parish record.

Cart-roads and foot-paths differ primarily in the use to which they are put. As to the width and nature of these species of highways the law provides that cart-roads must have a width of not less than 7 metres in towns, and 5 metres in the open country, clear of ditches, if any, and that foot-paths are to have a width of 1 metre.

Every parish is left free to determine itself the manner of raising the means for defraying that part of the expense of construction and repair of roads and ways which is not provided for by the state or the district. Some parishes have been authorized by the state or the district to levy tolls on certain roads serving principally for through transit, in order thus to meet part of the expense. These tolls are still collected, though they have been abolished on the state roads.

Owners of forests, rock quarries, factories, mills, and the like, who use roads on which toll is not permitted to be levied, for the carrying on of their business to such an extent as to cause a material part of the wear and tear, or to make necessary more frequent and more thorough repairs than would otherwise be required, can be held to the payment of a special sum, in proportion to the expense thus occasioned to the parish. In case of dispute, the amount of this special contribution is fixed by the "amtshauptmannschaften" in accordance with the judgment of experts.

(3) *Streets.*—Most of the provisions applicable to country roads apply also to village streets. As a rule the construction and repair of the streets are to be borne by the parish. However, when additions are made to a town necessitating the construction of new streets to connect the new addition with the older portion of the town, or to connect the different parts of the new addition with each other, the parish in authorizing the admission of the new territory may require the owners of the land embraced therein to furnish the necessary rights of way free of charge, or even to construct the new roads themselves, the parish merely assuming the subsequent repairs. Nowadays the latter mode has been generally adopted by cities and populous parishes; the rule is that whoever seeks to convert acre property into building lots must construct the necessary streets, bridges, culverts, etc., and transfer them to the city gratuitously, together with the title to the soil. These roads, etc., must extend the full width which the lots on which it is intended to build front on the projected roads, counting not only the width of the house, but also the gardens, courtyards, etc., and are to be carried to their junction with other projected or existing roads.

If the land composing the addition is the property of different owners, the one building first must construct the necessary roads, but as soon as the others begin to build they must pay the former or his heirs or successors a pro rata sum, depending on the width of their lots which front on the new roads.

It is usually provided in the city building ordinances that when the public interests require the continuation, widening, or correction of streets, ways, or public squares, or the construction of new ones, or the building or widening of bridges, levees or dikes, or the construction of culverts or drains, the owners of the land adjoining the proposed works are required to allow the authorities to make all proper use of their land—even though it be covered with buildings—and to cede to the city such portions as are needed, in consideration of a reasonable indemnification.

Before, however, private property can be taken for public purposes in this manner, the department of the interior must have declared it to be in the interests of the public and must have authorized the necessary condemnations.

(4) *Private ways.*—Private ways, built by land-owners on their own land in order to facilitate the cultivation and use thereof, are not subject to any ministerial regulations, being properly objects of private law. Only in so far as they may give rise to considerations of a general police nature, would it become the right and duty of the authorities to occupy themselves therewith and to issue instructions relating thereto.

As a principle of common law the rule obtains that the owner of a tract of land may require his neighbors to permit him to pass over their land, granting him a so-called "way of necessity" when without such way of necessity the cultivation of his land would be impossible, or when the establishment of a different way than the one he asks for, or the use of another existing way, would be attended by difficulties out of all proportion to the profits yielded by the land. Reasonable compensation must be made for the use of such a way.

An arbitrary change in the manner of using the land, or the mere personal convenience of its owner, do not entitle the latter to demand a way of necessity. Such easements are to be limited to the actual necessity, and their location and direction are to be determined in order that, on the one hand, the servient tenement may suffer the least possible damage, and that, on the other, the expense to the owner of the dominant tenement may not become unreasonably great.

CONSTRUCTION AND REPAIR OF STATE ROADS.

No new instructions have been recently issued regarding the rules to be observed in the construction of new state roads. There is no necessity for general instructions on this subject, as such roads are always built in accordance with plans prepared by the state engineers, based on a due consideration of the local needs and of the available funds; and as a these plans must first be examined and approved by the highest road authorities, the latter always have the opportunity of prescribing such special directions as former experience and the latest developments in the act of road-building seem to render advisable.

A circular instruction issued by the department of the interior several years ago, and addressed to the parishes, though dealing primarily with the country roads—which are not state roads—serves to give an approximate idea as to what, in the eyes of the state, are the essential elements of a satisfactory and methodical road system.

According to this circular, every road is to consist of a rock substructure and of a rock superstructure. The former supports the latter and prevents its sinking into the ground.

The superstructure constitutes the wearing surface of the road; it protects the substructure against wear as well as against the penetration of dampness with its injurious effects. The material employed should always be the best that can be obtained in the respective localities, the best varieties of rock being basalt, porphyry, finely-grained granite, and clear quartz.

The rock substructure—foundation—is to consist of broken stone, carefully placed by hand on the smoothed and graded roadbed, and to have a height of 12 centimetres if the rock is hard, and of 15 centimetres if it is soft. The pieces of broken stone are to be as nearly as possible of equal size, and are to be placed tightly against each other, each one with its largest plain surface downwards to prevent its working loose. The intervening spaces are filled up with small fragments, carefully wedged in and rammed down.

On this foundation is placed a superstructure consisting of a layer of 8 to 10 centimetres depth of small broken stone, the pieces as nearly as may be of equal size, or of gravel. In order to obtain a surface as smooth as possible the broken stone composing the superstructure should approach a cubical form as nearly as may be, and should be of the size of a hen's egg or a walnut, depending on the quality of the material. The road is next thoroughly soaked with water, and passed over several times with a heavy roller. It then receives a covering of fine gravel or pebbles, and is solidified by careful rolling.

In order to secure a rapid drainage of the road and to keep the roadbed dry, the surface must be convex—a central elevation of one-sixteenth to one-eighteenth of the half width of the road being sufficient—and the road must be provided with ditches on both sides, having a depth of not less than 0.3 metres and a width at the bottom of 0.3 metres. In level country the grade of the road should never exceed one-fourth inch, and in mountains one-twelfth inch. At heavy curves the road should be as level as possible, and its width should be increased by one-fourth to one-half.

The rules to be observed in keeping the public roads in repair have been quite fully set forth, partly in the form of general instructions, partly as specific regulations issued to the road employés.

A distinction is made between general repairs, undertaken to make good the deterioration of the entire roadbed by the action of the weather and traffic, and local repairs, which are continually necessary to correct

the partial wearing out of the surface by mechanical action, as evidenced in the form of ruts and depressions.

General repairs consist in covering the entire surface of the road with a massive layer of broken stone, which is thoroughly rolled down so as to fill out all depressions. When a considerable portion of a road is to be covered with new material, the work is to be performed in short sections if the street is narrow; if wide, the material is to be spread in narrow longitudinal strips, so that not more than one-half the width of the road is being worked at the same time, and only when the first half is completed is the second to be begun. The road, when thus covered with new material, is to receive a suitable covering, which however, is not to be applied until the mass of rock has been sufficiently rolled to acquire a certain degree of solidity and to cause the intervening spaces to disappear.

As has been stated, a street-roller is employed for compressing the mass of broken rock. The rolling is done longitudinally, moving gradually from the edges toward the center, and, when practicable, is to be kept up until the mass of new matter is thoroughly fixed. The mass is to be moistened by continued sprinkling, in order to insure its more perfect solidification. It has been found that the seasons best adapted for making general repairs are the spring months until the middle or end of June, and the months of September and October. The winter months are not advantageous, even though the weather be mild, for it has been found to be an essential condition of durability that the new material be thoroughly dried and hardened before it is subjected to the action of the frost.

The frequency with which general repairs need be made is variable, but averages for the state roads from 11 to 12 years.

In order to insure the greatest possible durability of the road surface, care should be taken that the covering of new material be not too thin at places. The old road surface should therefore be specially prepared for the reception of the new covering by paring down the protuberances and carefully reëstablishing the profile.

When general repairs have been made, the surface of the road usually remains quite smooth for years if the traffic is but moderate. However, more or less unevenness develops in the course of time, and to counteract the formation and enlarging of rough spots as much as possible is the chief object of the continuous local repairs.

Finely-broken rock, either specially prepared or obtained by sifting the coarser material intended for road covering, is employed for making the local repairs. Depressions in the road are filled up not only to preserve the smoothness, but also because vehicles avoid such defective spots and thus wear out the rest of the surface all the quicker. For this reason the places to be repaired are to be selected in such a manner as will tend to a uniform wearing of the whole road surface. As a further means of obtaining the latter result, the track to be followed by

vehicles may be fixed by placing obstructing stones * on the road, which, however, must be removed at night. This is to be done only in damp weather, on roads used for heavy hauling, and then only to a limited extent at a time.

When defects can be remedied with a small quantity of new matter it is sometimes advantageous to loosen the edges with a pick, in order to obtain a thorough union with the old and new material. The loose matter should be moistened and carefully rammed down and covered over. This method is, however, employed to a limited extent only, as it is rather expensive. Local repairs should always be carefully conducted in order that the solidification may take place as speedily as practicable. They should for the same reason never be undertaken for a large stretch of road at a time, so that, if dry weather should set in, delaying the process of consolidation, the traffic may not be unduly interfered with.

Not until the mass of material spread at the last general overhauling has practically disappeared are general repairs again necessary. As the surface does not wear off uniformly, the smoothness of the road has usually suffered material diminution before a new overhauling is undertaken. In some instances the system of repair here outlined proves insufficient, even though the road be otherwise strong enough. Thus, in villages where the road is well built up the street crossings are used by large numbers of pedestrians, who, as a rule, are more exacting as to the condition of roads, especially in wet weather, than the drivers of vehicles. In such cases a stone pavement or some other substantial substitute for the macadamized surface becomes necessary.

If, however, the road itself is lacking in power of resistance, it is necessary to strengthen the roadbed and at the same time take measures looking to a uniform wearing off of the entire road surface.

Where the traffic is neither large nor heavy, and the defects of the roads are unimportant, the movement of vehicles will not be apt to suffer in case of bad weather, and even if affected, it will be for a short time only. In such cases it will be sufficient to aim at maintaining the *status quo* by providing somewhat more new material than will equal the amount worn off, thus counteracting the deterioration of the roadbed resulting from the occasional interruption of the continuity of repairs.

If, on the other hand, the vehicles passing are both heavy and numerous, and the defects of the road more serious, interruptions of communications are to be looked for more frequently and are apt to be of longer duration and greater importance. In such cases it is plainly imperative to try to restore normal conditions as speedily as may

* The dimensions of these obstructing stones should be one-third metre. To make them easily visible, they are to be painted white. They are to be placed on the road in such a manner as to keep the traffic off that portion of the road which it is the desire to withdraw from public use.

be. This applies especially to roads whose defective portions are of but small extent, and to such as suddenly become quite or wholly impassable. Cases falling between the two extremes cited must be met according to circumstances. It may be advisable at times to refrain from any attempt looking to a complete restoration, merely striving to limit the extent of the defects.

As to the manner of procedure to give the roadbed greater power of resistance, it has been found that increasing the thickness of the superstructure, or merely renewing it with greater frequency, is the simplest method and accomplished with the least interruptions of traffic. In so far as new material is used merely to increase the thickness of the superstructure without being exposed to surface wear, a substance of moderate quality will answer, the better and more expensive material being reserved for the surface covering.

Where, however, the roadb ed contains springs the method above set forth is not always effective; it is generally necessary to secure better drainage by widening and deepening the ditches, and digging new ones, if there are not already enough. Underground drainage is now being introduced for such cases, a trench of 0.4 to 0.6 metre in width being run longitudinally under the center of the road, and filled up with loose stone and rough gravel to the rock superstructure of the road. Tranverse trenches from 0.3 to 0.4 metre in width serve to conduct the water out of the roadbed.

Even in this way a complete success has not always been attained. Some kinds of soil are not sufficiently porous to admit of thorough drainage in this manner. In many cases, too, the deficient depth of the ditches renders it difficult to locate the drains at a sufficient depth and at the same time permit the water to flow out into the ditches. Accordingly, when a system of underground drainage promises but incomplete success it will be well to combine with it a reënforcement of the superstructure of the road, in some cases even to construct a new roadbed supplied with extra thickness of rock layers.

If, however, as happens in the most difficult cases, the level of the roads makes satisfactory drainage impossible, a complete success can not be achieved without changing the level, or, what amounts to the same, entirely rebuilding that section of the road.

When it is the intention to pave certain portions of a road, care must be taken to give the substructure the necessary strength and solidity.

The detailed instructions issued for the guidance of the roads employés are in accordance with the general rules as above set forth.

It is the duty of the roadguards to carefully ram down all newly spread material that has not yet been thoroughly fixed. If in places the material was not sufficient, and ruts again make their appearance, the guard is likewise to apply new matter with proper care. He is to pare down all ridges and projections, and work the loose matter into the depressions, in order that the road may be smooth and retain its

original convexity, and if necessary he is to put on enough new material to attain this end. The mud gathering on the road is to be carefully scraped off, especially when a spell of wet weather sets in. The dust that accumulates in dry weather is likewise to be removed, care being taken to pick out the loose stones. The guard is furthermore to stop up all holes in the body of the road or the sides of the ditches, using for this purpose the mud that has been scraped off the road, to clean the ditches, destroy the weeds that make their appearance on the roadside, keep the bridges and culverts unobstructed and in good condition, open the drains and put them into repair.

When snow has fallen heavily or is drifting, the roadguard must shovel it off the road so as to keep a track open. If he is unable to do this with the assistance of hired day laborers, he must make requisition on the parish authorities for the necessary help. If, on account of continued drifting, the road can not be kept open, the travel is to be temporarily led over the adjoining fields, care being taken to mark the location of the temporary road by poles and wisps of straw. When the weather permits sleighing for some time, loose stones and gravel liable to cause accidents are to be removed, and bare spots are to be covered with snow.

When thaw sets in, all snow and ice on the roads must be speedily removed.

Another though comparatively subordinate charge on the road authorities is the planting of trees along the road and taking care of them. As a general rule, trees must be planted along every road.

This is done partly to render the direction and the limits of the road more plainly visible in the dark and when the snow is drifting, partly to delight the traveling public. In the choice of trees to be planted climatic conditions merit first consideration, attention being, however, also given toward securing the greatest possible returns from the trees. For this reason fruit trees are preferred wherever practicable, otherwise those forest trees whose wood has the greatest commercial value.

In so far as professional knowledge is not required, the roadguards are also charged with the pruning, removal of insects, clearing of tree frames, watering those newly set out, and replacing those that fail to take root.

CONSTRUCTION AND REPAIR OF COUNTRY ROADS.

The rules governing parishes in the construction of country roads have been stated in the course of the remarks on state roads, to which reference is therefore made.

The circular to which reference has already been made also states the general rules to be observed in the repair of country roads in terms analogous to those concerning the repair of state roads. However, it does not contain fixed instructions which must be obeyed under all circumstances, but is rather a statement of facts and principles for the information of all concerned.

Specific instructions are issued by the "Amtshauptmannschaft" to meet the particular requirements of the individual cases of "country road" construction and repair. The only general provisions have been already set forth and concern the width of the street, the planting of trees wherever practicable, and in the default thereof the marking of the limits of the roads in some other permanent manner which may be efficient, especially in time of snow.

CONSTRUCTION AND REPAIR OF STREETS.

It is left to the individual parishes to regulate the construction and repair of their respective town and village streets. Of course the necessity of establishing special ordinances regarding streets exists only in the cities and populous parishes that have an extensive local traffic, and the nature of these ordinances varies with the varying local conditions. A general provision, however, requires streets to be composed of a substantial rock substructure and superstructure and of a suitable covering, the latter to consist of large flat rocks for the sidewalks. It hardly could be of interest to enter into the details of these ordinances. For those parts of city streets where wagons pass, the varied materials such as Belgian blocks, cobblestones, Nicholson pavement, asphalt, pressed slag, etc., are used for surface as they are in the United States. The manner of putting the materials used in the construction of city streets does not differ from that of our American cities.

Water and gas pipes are laid, and sewers, catch-basins, fireplugs, and manholes are constructed and placed similarly to the manner adopted in the United States. An extended report on city streets will be furnished at a later period if desired.

CULTIVATION OF TREES ON ROADS IN SAXONY.

The system of tree culture along the roads of Saxony is the admiration of every American who observes it. The beauty and picturesque appearance of long avenues of finely-selected and well-kept trees, stretching away for miles in various directions, gladdens the heart of every admirer of natural beauty. It is, as has been stated, a consideration of less importance than the building of the roads, but the following figures will show the value of a well governed and faithfully managed system of tree culture on the public highways.

In the year 1890 the noteworthy sum of 150,622.55 marks was obtained for the fruit grown along the state roads of Saxony. The district which collected the largest amount was the "Amtshauptmannschaft" Döbeln, which turned into the treasury 27,534.50 marks, while the mountain district, Annaberg, supplied the least, or only 15.50 marks.

The revenues from the fruit trees of the other districts was as follows:

	Marks.		Marks.
Pirna, I and II	21,713.90	Zittau	8,853.50
Grimma	18,077.65	Zwickau	6,538.20
Leipzig	17,216.00	Chemnitz	5,178.50
Bautzen	15,733.50	Freiberg	1,046.50
Dresden, I and II	15,638.50	Plauen	970.30
Meissen, I and II	11,536.95	Schwarzenberg	570.00

These figures refer to the state roads only. The income from trees along country roads is greater.

At the risk of repeating a few ideas which have been previously expressed in more general terms, I submit the following:

Object of planting trees.—Trees along the public roads make the border of the road discernible at night, as well as after snowdrifts, thereby warning the public against embankments and other danger along the sides of the road. Trees also afford pleasure and comfort to those who use the roads, and are a source of considerable revenue when properly cared for, as shown above.

In this connection care must be taken to secure the highest possible profit out of such trees in the interest of the road administration and the tax-paying public generally.

Selection of trees.—(1) In general such kinds of trees should be selected for road purposes, which, as far as the climate and condition of the soil permit, promise a good and speedy growth; that are not too sensitive to climatic and other influences and can soon stand without a prop, and that especially promise a remunerative return in proportion to the cost of their raising and nursing.

(2) In parts of the country where fruit trees grow, and where the crop is not in danger of damage by late spring frosts, such trees should by all means be cultivated. Forest trees are preferable where fruit trees can not be grown successfully, especially at high altitudes, and in forests, and also where wanton damage and considerable plundering of fruit may be apprehended, this being sometimes the case within and around thickly populated districts and near villages.

(3) In damp localities trees with broad thick foliage, and on narrow roads short-stemmed trees with wide extending branches should not be planted.

(4) It is also advisable, if possible, to avoid the planting of such kinds of trees as would prove to be directly injurious to the adjoining property.

(5) With special reference to fruit trees, the planting of such trees is recommended as bloom and ripen late, and the fruits of which will stand a long journey and will keep comparatively a long time without spoiling. In order to facilitate the leasing of such fruit trees it is recommended to cultivate the same kind of fruit on rather long stretches of road. In case special local conditions do not make this appear profitable, such varieties of fruit should be planted as will at least ripen at

the same time and always in such number that a proper and reasonable use may be made of the crop and a favorable leasing rendered practicable. Avoid, if possible, the planting of timber trees in between fruit trees.

(6) If apple trees are planted varieties having long stems and lofty tops should be used, if possible. It is not recommended to plant trees in deep or narrow valleys.

(7) For timber trees such kinds should be given preference as can be profitably used for choice woods for special purposes. In Saxony the planting of ash and maple trees, and, in considerable distance from villages, wild cherry trees is specially noticeable. Where the soil is unfavorable, especially in mountainous districts where other kinds of trees do not grow as well, mountain ash trees may be recommended.

(8) Generally speaking, particular attention should be given to young, strong, and well nursed fruit trees of such pedigree as are best adapted to a given part of the country.

(9) If trees have been cultivated which do not correspond with the principles laid down in Nos. 1 to 7, endeavor by degrees to substitute a more preferable system of transplanting.

(10) For such renewal of trees a systematic plan must be adopted and followed with all the supplements rendered necessary in Part V of these instructions.

(11) A change in the system of planting is not objectionable in cases where existing fruit trees can be expected to yield a larger crop by removing timber trees growing between the fruit trees and also barren fruit trees.

(12) When it is ascertained that a change in the kind of trees will cause a more remunerative crop, which will outweigh the costs and damages of the change, the same can be brought about little by little annually on stretches from 5 to 10 kilometers of road. A radical change should always be justified by circumstances, as such a course is unusual, and the same should be explained by a detailed statement made to the chief supervisors of the roads in the district.

Rules of tree cultivation.—The distance between the trees should be based upon the purposes mentioned in Part I. It should, however, not be too small in order not to injure the growth of the trees. When the security of the traffic does not demand a closer planting, apple, pear, and sweet cherry trees should stand 30 to 40 yards apart; sour cherry trees and plums 7 to 9 yards.

Local conditions govern the planting of trees along certain parts of the roads where tree planting appears impracticable, because of the roadsides being abrupt and rocky, or when trees or houses stand in immediate vicinity of the road.

When trees are set out hollow places should be left at their bases for irrigating and other purposes, which should not be too small. Where trees already stand and these "hollows" are wanting, they should be

gradually formed by suspending the periodical trimming of the edge of the road or by banking up a basin-like substitute therefor.

The holes for planting the trees should not be too small, especially when the road lies in a cut or when the planting is to be done on spots where other trees have stood formerly. The holes should be, for fruit trees, from 3 to 4½ feet wide when the soil is rich, and 5 feet when the soil is inferior. The depth should be according to the good or inferior soil: 2 to 3 feet, less than 1½ feet only being practicable for plum trees. Where these holes can not be dug in the prescribed dimensions, then they should be dug out in shape of a ditch, so that the roots of the tree can at least find loose soil in two directions. These holes should be filled with earth mixed with compost.

Should a renewal in the planting on long distances be found necessary, the new trees should be planted between the spots where the old trees stood, and eventually the kind of tree changed.

The poles destined to prop up the young trees should be polished and blunted on the upper end, in order to prevent them from rubbing against the trees. These poles should be fixed on the side which is mostly exposed to strong winds; it must, however, also be borne in mind that these poles protect the trees from damage from the road. The bands should always be attached in the shape of an **8**, and, when fastened, special care should be taken to prevent the pole from rubbing on the tree.

When grafted fruit trees are to be used care should be taken that the desired species be obtained under guaranty. In cases of extensive plantings, when the desired species can not be obtained with certainty, it is recommended to plant wild trees that can be properly grafted when the time comes.

The trees should neither be planted in damp nor cold weather, but in weather when the soil that has been prepared crumbles easily, and therefore can be easily placed between the roots. Apples and pears can be planted in spring as well as in autumn; for cherries and plums, spring is preferable. The latter only require alluvial "mud dressing." When setting out trees the sinking of the soil must be taken into consideration if the same is specially heavy. The tree must not be put as deep in the earth as it grew originally, so that the proper depth of planting is not surpassed by the gradual sinking of the soil around the roots. When the new trees are tied to posts, care must be taken that they are not prevented from settling themselves firmly in the soil. The final fastening to props can only be done when the earth surrounding the roots has settled down.

Nursing and keeping trees.—When dry weather prevails the tree "hollows" should be covered with moss, inverted sod, or similar substances. Newly transplanted and young trees should be provided with the necessary moisture by flooding water into the "hollows," if this does not cause a too heavy expenditure. Where the tree "hollows"

are very small or are completely wanting, two or three holes should be dug around the tree and filled with water. These holes must be kept open with drainage tubes.

To protect young trees against rabbits and hares in winter, or other damages, the stems should be tied up with thorns, straw, or reeds. Wire should be used for this purpose. To protect the trees against insects and to prevent the bursting of the bark in winter, the stems of the fruit trees should in the fall of the year be whitewashed, or covered with a mixture of lime and ox blood, compost, clay, or similar substance. A straw or moss covering is considered a good protection against the drying out of young trees that are especially exposed to the sun and wind.

The earth in tree "hollows," especially those of younger fruit trees, should be frequently loosened.

The so-called "suckers" should be cut off at all times, if they are not required to fill out the tree top or for substitution in places of old boughs. In the latter case they should be nursed with special care. In order to cause a good growth of the fruit-bearing top of fruit trees, careful pruning is necessary at certain periods, as well as a clearing of old trees from useless or too numerous branches.

In general, the nursing of trees along state roads should not suffer by comparison with trees along the roads kept up by communities or private individuals.

The cutting of the young fruit trees should only be done by specially skillful persons. Such employés as have been educated for such purposes are to be preferred.

The pruning of fruit-bearing trees may be done by inexperienced employés when such work is superintended by experts.

Cutting down of trees.—The cutting down of either fruit or forest trees on roads is permitted only when such a proceeding promises to be profitable, with reference to a subsequent increase in the value of the timber trees to be substituted for those removed, or in the value of future fruit crops. The costs of replacing and cultivating young trees must be carefully considered.

The ornamental point of view should not be overlooked, especially on avenues of trees that beautify that part of the country where they exist. Such trees should not be cut down without the knowledge and the consent of the county commissioners.

Dead or badly damaged trees which destroy the beauty of the avenue and which, being liable to break down in storms, threaten to interfere with the proper use of the road, should be removed without delay.

The trees should be cut down in a season in which the wood can be most profitably used.

Wherever trees insure the safety of the roads a renewal of removed or dead trees should take place without delay. If replanting is not

practicable, on account of the season, poles should temporarily replace the trees.

General instructions.—Special care must be taken to secure in time the necessary quantity of trees to be used each season.

Road employés should not be permitted to lease fruit trees or to buy the wood, except in cases where other parties fail to make bids which are satisfactory.

State-road fruit trees are leased to the highest bidders and the money received is covered into the state treasury. Wood from road trees is sold at auction and the money returned to the public treasury. Nothing is lost or wasted, and those who lease fruit trees are held to a strict account for any damage done the trees. Ladders must be used to gather the fruit, and any battering of the trees with clubs or poles to get fruit is sharply punished.

GENERALIZATIONS.

In conclusion, it will not be inappropriate to mention some general facts of more or less importance which have been omitted from the foregoing, and to review briefly some provisions of the laws by which, in the interests of the general public, the executive governing powers seek to prevent certain of the damages which might otherwise ensue.

There are no statistics which show the total length of the combined roads and streets of the Kingdom of Saxony.

Of state roads there are 37,032 kilometres. The average cost per annum of keeping the state roads in the splendid condition which always exists is 650 marks per kilometre, while the beautiful macadamized country roads require an average annual expenditure of 400 marks per kilometre to maintain their never-failing excellence.

These figures do not include the salaries of the employés who protect and tend the roads. The following salaries are paid to road employés:

	Marks.
Road inspectors	3,300 to 4,800
Road masters	1,500 to 1,800
Road guards	660 to 720

Laborers receive about 75 cents per day. Road masters and guards are gratuitously uniformed and are allowed 80 to 90 marks per annum with which to keep their uniforms in repair. They present a neat appearance, and are careful in the discharge of their duties.

The rollers or surface crushers in use are for both horse and steam power. The horse-power rollers weigh from 12,000 to 15,000 pounds and cost from $350 to $400. Gruson steel tires cost $100 extra. The steam rollers are built after the system of Arding & Porter, of Rochester, and weigh 22,000 pounds. They cost $3,000. Heavier rollers are not practicable because of the hilly condition of the country.

None of the roads in Saxony are fenced. They are so clearly defined by the trees which grow along their sides, and by other boundaries,

that fencing is unnecessary. In this connection I will report that, with the exception of a few picketed inclosures, there are no fenced grounds in all Saxony.

The charming appearance of this Kingdom owes much of its beauty to the fact that its wide, well-tilled valleys, its rolling hills crested with dark pine forests, and its fruitful plains are not disfigured by fences of any kind.

If the same economy were practiced in the United States our people would be much richer, for it is a fact that the farm fences (road and line) cost more than all the farm buildings in our land.

Even the railways in Saxony are unfenced. Crossings on the level are guarded by descending barriers, even in the places remote from towns and villages. Only on such railways as are narrow gauge and called "secundär" railroads, it is possible to find level crossings which are unguarded by employés hired and paid by the railroads. In such places warning signs and the locomotive bell guard the traveler on the turnpike.

On all wagon roads where steep, abrupt embankments endanger passengers or teams of horses, a barricade is usually built of stone posts connected with heavy angle-iron bolted firmly into place.

Square cut stones show distances in kilometres and fractions thereof. These posts are painted white, and the figures on them are carved deeply.

At crossing or diverging ways substantial iron direction plates tell the distances to various towns or hamlets. In the highlands and mountainous parts a society, called the Austro-German Tourists' Club, has erected hundreds of guideboards for the use of its members and others who are making tours afoot through the enticing and picturesque parts of the country.

There are no special rules giving to pedestrians' rights of way over conveyances of any kind. Drivers must, however, keep off that part of the road which is reserved for and made use of by foot passengers. Horses must be turned to the right when meeting, and several penal regulations prohibit fast driving or any reckless behavior on the roads.

Not only the Royal Government, but all local police authorities hold a firm check on any disregard of general rights which the public enjoy in the use of the Saxon roads.

All wagons must carry a lighted lantern at night, and keep to the right-hand side of the road. All wagons used for heavy teaming are required to be conspicuously and plainly marked in large and durable letters, with the name and residence of the owner. Horses must be driven under control of "crossed reins" as in America, and only when engaged in field work are they not subject to this regulation.

Wheelmen are not granted any special rights on roads. On the contrary, they are required to ride with the utmost caution and care.

In detail, according to differing local conditions the instructions to wheelmen differ as far as police regulations apply. But, in general, wheelmen are subject to the same rules as apply to drivers of horses. They must provide lamps for their wheels; keep to the right; carry a metal shield on the front of the wheel with name and address engraved on it; keep off the footpaths; ring a bell when approaching any one, and in some cases abstain from riding side by side. When riding in files a given distance must intervene between them and those who precede them. Wheelmen, as such, pay no taxes.

Fines collected for the violation of road laws go into the treasury of the authority which imposes the fines. On state roads the money would go to the uses of the "Amtshauptmannschaften," and on country roads to the local police fund.

On some state roads heavily-laden vehicles are required to have a certain minimum width of tire, while wagons having boltheads or screws protruding from the tire, or having tires with a rounded surface, are not permitted to enter the road at all. Drivers of heavily loaded wagons pursuing a track already well worn must drive on a different part of the road when so directed by any of the road employés.

It is further prohibited to drive in or across ditches or on the footpaths, or to ride, or to drive cattle at these places, as also to drag on the road timber, farm implements, or other articles that damage the surface of the road, or to do any other act injurious to a public road or its appurtenances. A fixed width of tire to correspond to the weight of the load is also sometimes required by local police regulations.

While a violation of the above regulations constitutes merely an offense cognizable by a police court, the willful destruction or injury of roads, or of the trees thereunto belonging, is regarded as a misdemeanor punishable by the proper court.

H. F. MERRITT,
Consul.

UNITED STATES CONSULATE.
Chemnitz, April 10, 1891.

SAXONY.

REPORT BY CONSUL PALMER, OF DRESDEN.

INTRODUCTION.

The division of the public roads in the kingdom of Saxony into city streets and country roads is rendered necessary not only by the fact that their construction and method of maintenance are entirely different, but also because they are under the control of two administrations that are strictly independent of each other.

It will be sufficient to furnish a detailed report on streets in larger cities (in this case Dresden being selected), for the reason that, usually, the streets in smaller towns and villages are built on the same principle as the less important streets in large cities, and further because the same administrative laws and regulations prevail in larger cities as in smaller towns.

The roads in the open country are divided into two classes: (1) State or governmont roads. (2) Country or communication roads (connecting two or more towns or villages). The former are maintained at the cost of the state, by a special department, which also supervises the navigable ways. The latter are built and maintained by the city and country communities, and by the owners of independent estates whose lands they cross; in some cases, also, by all parishes within one "amtshauptmannschaft" (district commission) voluntarily united for that purpose.

The "communication" roads are, ordinarily, used for smaller traffic and serve mostly for agricultural purposes. Their system of construction and repair is in no way different from that of state roads and they may safely be classed with inferior state roads. For this reason no special description will be given of these roads, but, as far as it will appear necessary, they may be referred to occasionally.

In the entire kingdom of Saxony no distinction is made between roads for light and such for heavy vehicles. The public roads are, in general, open to traffic of every description, and therefore they should be built and maintained in accordance with such requirements. In the city of Dresden the transportation of heavy loads that can not be separated is only permitted under the condition that such vehicle be tested by officials in reference to its loading capacity, and that the condition of the foundation, sewerage, etc., of the streets through which such heavy loads are destined to pass be thoroughly examined.

Similar regulations exist in reference to state roads and for crossing over bridges.

CITY STREETS.

The primary difference between city streets and country roads consists in their different manner of drainage. The latter are drained by means of longitudinal ditches on each side of the road, the former only by underground sewers located in most cases in the middle of the street. These sewers not only serve to drain all waste water from the houses without detriment to the inhabitants, but also make it possible to provide the street with elevated sidewalks.

Beyond this the constant traffic in cities, and care for the health of the inhabitants requires a far greater durability and solidity of construction of city streets and sidewalks, and more care must be bestowed on their maintenance than is the case on country roads. Almost all city streets in Saxony are paved.

Recently, beaten asphalt is being used in the busiest streets of larger cities instead of stone pavement. Wood pavement was also tried, but did not fully meet the expectations, and after several trials this system was altogether abandoned, the wood was removed and replaced by asphalt.

In parts of cities where there are only detached residences (villas) macadamized roads are preferred.

COST OF MATERIALS.—The cost of materials for street and road building, exclusive of all costs of transportation from the different quarries may be averaged as follows:

Rough paving stones from the quarries of Planeusche Grund, from Pennrich, and Prabschütz, 2.70 marks per square metre equal to 2.25 marks per square yard.

Rough paving stones from the quarries near Meissen, from Schönborn and Demitz, 2.15 marks per square metre equal to 1.80 marks per square yard.

Dressed paving stone from the quarries of Luptitz and Grimma, Dornreichenbach and Haida: first class, 6.75 marks per square metre, equal to 5.65 marks per square yard; second class, 6.35 marks per square metre, equal to 5.30 marks per square yard; third class, 5.45 marks per square metre, equal to 4.55 marks per square yard.

Dressed paving stones of all three classes from quarries Bullevitz and Niederiocesa, 8.60 marks per square metre, equal to 7.20 marks per square yard.

Cast slag paving stones, 3.80 marks per square metre, equal to 3.15 marks per square yard.

Gravel from the river Elbe, 1.50 marks per cubic metre, equal to 1.15 marks per cubic yard.

Pit gravel (mine gravel), 1.50 marks per cubic metre, equal to 1.15 marks per cubic yard.

Sand, 0.80 mark per cubic metre, equal to 0.61 mark per cubic yard.

Extra solid and weatherproof coarse quarry stones used for "packing layer," 1.50 marks per cubic metre, equal to 1.15 marks per cubic yard.

Coarse broken stones (same quality as above), not exceeding 8 centimetres in size, 2.00 marks per cubic metre, equal to 1.53 marks per cubic yard.

Small broken stones (same stone as above), not exceeding 5 centimetres in size, 3 marks per cubic metre, equal to 2.30 marks per cubic yard.

Small broken basalt stones (not exceeding 4 centimetres in size), from Tischlowitz quarries, 3.50 marks per cubic metre, equal to 2.65 marks per cubic yard.

Small broken basalt stones (not exceeding 4 centimeters in size), from Praskowitz quarries, 4.15 marks per cubic metre, equal to 3.17 marks per cubic yard.

Small broken pieces of porphyry, 1.60 marks per cubic metre, equal to 1.22 marks per cubic yard.

Small broken pieces of "grünstein" (greenstone), 3.00 marks per cubic metre, equal to 2.30 marks per cubic yard.

Finely broken "greenstone," 3.50 marks per cubic metre, equal to 2.65 marks per cubic yard.

Asphalt powder, 7.70 marks per 100 kilograms.

Dressed paving stones from the quartz porphyry quarries near Brussels, Belgium, measure being taken upon the completed pavement, free delivery to the place of construction. First class, 4.50 marks per square metre, equal to 3.75 marks per square yard; second class, 3.50 marks per square metre, equal to 2.92 marks per square yard.

MATERIAL USED FOR ROAD BUILDING AND STREET PAVING.

The kinds of stones universally used for building roads and paving streets are the following: Dressed paving stones of "grünstein" (greenstone), specific weight, 3.2; quartz-porphyry, syenite, granite, specific weight 2.8; rough irregular paving stones of granite and syenite, shaped at the quarries before they are made use of; artificial paving stones cast from copper slags; small, broken pieces of basalt, of syenite, and of "greenstone;" beaten asphalt is obtained from Val de France, Seysel, and Sicily. It is delivered pulverized and ready for use.

The dressed paving stones are divided according to their size into three classes.

Of first-class stones about 27 will form 1 square yard (32 to 1 square metre). They must measure 0.185 to 0.21 yard (17 to 19 centimetres) in height, and 0.155 to 0.185 yard (14 to 17 centimetres) in width.

Of second-class stones about 33 will form 1 square yard (39 to 1 square metre). Height required, 0.165 to 0.185 yard (15 to 17 centimetres); width required, 0.130 to 0.165 yard (12 to 15 centimetres).

Of third-class stones about 42 will form 1 square yard (50 to 1 square metre). Height required, 0.14 to 0.165 yard (13 to 15 centimetres); width required, 0.11 to 0.14 yard (10 to 13 centimetres).

The length of the stones of all three classes is proportionate to their width as 5 to 3.

The top of the stone must be even and have sharp, regular edges. Their shape must be like a truncated pyramid, and should resemble as much as possible a prism. The incline of the sides must not exceed one-tenth of the height.

Natural stones hewn into exact cubic shape are not used, this process being too expensive; but paving stones cast from copper slags are delivered and used in that shape.

During the year 1890 the demand for good paving stones was so great that they had to be purchased in large quantities from the quartz porphyry quarries near Brussels, in Belgium. The stones purchased from these quarries are of two (first and second) classes, and prices

have been stated above. Experience will show whether it be profitable to use these stones for other purposes or not.

CONSTRUCTION AND REPAIR OF STREETS.

Macadamized streets.—Every macadamized street must, according to the law, consist of a rock substructure and a rock superstructure. The substructure supports the superstructure and prevents it from sinking into the ground. The superstructure forms the wearing surface of the street and protects the roadbed against dampness with its injurious effects. Whenever a street or carriage road is constructed, the soil on which the rock substructure is to be placed is, after necessary drainage, thoroughly soaked with water and then rolled tight with a street-roller, which is either drawn by horses or propelled by steam power, until the surface becomes completely smooth.

The substructure consists either of a layer of coarse broken stone (the single stone not exceeding 0.09 yard [=8 centimetres] in size), see Fig. 1, or of a row of large stones, so-called "packing layer," see Fig. 2.

Fig. 1.

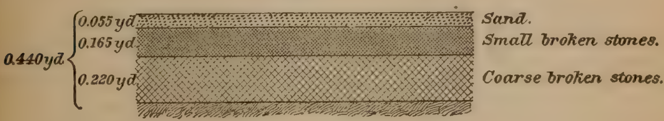
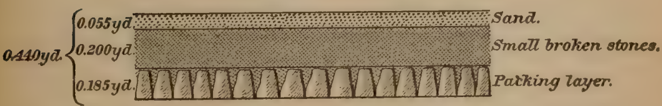


Fig. 2.



The substructure of coarse broken stone is used in such cases when the soil or foundation is found to be soft and not resistant. This layer must be at least 20 centimetres thick and is but slightly rolled before placing on the superstructure. (Fig. 1.)

If the natural foundation is solid the substructure generally consists of large quarry stones, not exceeding 0.19 yard (17 centimetres in height. (Fig. 2.)

These stones form the so-called "packing layer," and are carefully placed by hand on the smoothed and graded roadbed in close rows with their broadest side downwards and their points turned upwards to prevent their working loose. The spaces between these stones are filled out with smaller stones and the projecting tops, if any, knocked off. (Fig. 2.)

In both cases a layer of small broken stone is spread on the substructure. thus forming the superstructure.

With reference to Fig. 1 this superstructure must be at least 0.16 yard (15 centimetres) thick to Fig. 2 at least 0.2 yard (18 centimetres) thick.

Before spreading, these small stones must be passed through a screen, so as to free them from all dust and earth; their size must not exceed 0.055 yard (5 centimetres) and not be smaller than 0.044 yard (4 centimetres), according to the firmness of the rock used.

It must not be omitted to state that this superstructure of small broken stone consists of two separate layers, each layer being separately rolled tight, while soaked with water, thus increasing its firmness. When the desired road profile is obtained and the stones lie closely and firmly together, the dust, earth, and gravel left from the screening of the stones is spread over the surface.

The roller is then again passed over, and the road is completed with a layer (about 0.055 yards thick) of moist, binding gravel sand.

It may be well to add here that the rollers used for crushing the surface of the roads or streets, called "compression rollers," are either drawn by horses and weigh about 6,000 kilograms, or propelled by steam power and weigh from 10,000 to 15,000 kilograms.

The former can compact 52 cubic yards (40 cubic metres) per day, and the latter from 80 to 100 cubic yards (60 to 80 cubic meters) per day.

The figures showing the thickness of the different stone layers that compose the substructure and superstructure of a macadamized street, as indicated in red ink on the above diagrams, are understood when the street or road is completed and ready for public use; if, however, such measurements were taken before the street bedding has been compacted, the quantity of material required would be from one-fifth to one-eighth larger.

Every street or road must be arched, the highest elevation thus obtained measuring one-sixtieth of the width (exclusive of sidewalks) for macadamaized streets, one-eightieth for paved streets, and one one-hundred-and-twentieth for asphalt streets. (Figs. 1, 2, 3.)

The curbstones of the sidewalks are located from 0.11 to 0.13 yards (10 to 12 centimetres), above the street surface; the sectional inclination of the sidewalks being fixed at one-thirty-third, their width being under normal conditions one-fifth of the entire width of the street, three-fifths, therefore, remaining for the carriage road. (See Figs. 1, 2, and 3).

City streets are generally wider than country roads.

The width of state roads varies between 6.6 and 10 9 yards (6 and 10 metres), and the width of country ("communication") roads must be at least 5.5 yards (5 metres) in open country and 7.7 yards (7 metres) within villages or towns. In Dresden all new streets must measure at least 14.2 yards (13 metres), increased to 34.9 yards (32 metres) and more, if necessary. It may be stated that the average width is figured

at 21.8 yards (20 metres). Based upon the above-mentioned widths, the proportion of the sidewalks to the main carriage road of one-fifth to three-fifths is maintained.

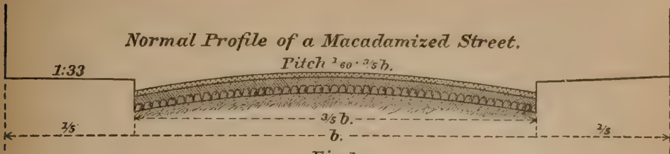


Fig. 1.

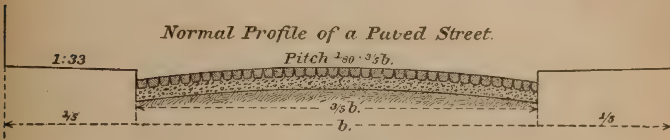


Fig. 2.

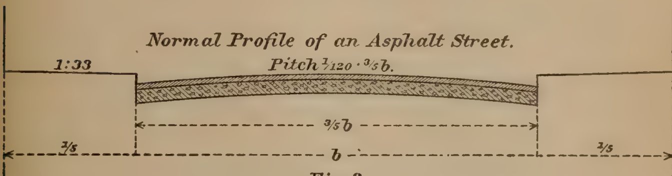


Fig. 3.

Should any division different from the above be decided upon it is always in favor of the sidewalks, according to the local requirements. It occurs, for instance, that very broad streets are provided with a central elevated promenade reserved for pedestrians only.

In order to prevent the rain-water from stagnating on the side of the street and to conduct it into the sewer openings the street must have below the curbstones a longitudinal incline of at least 1 to 250 alternately in both directions; the minimum for this incline is 1 to 300.

PAVED STREETS.

As above mentioned almost all city streets in Saxony are paved. The bedding on which the paving stones are placed consists in all cases of gravel sand, called paving sand (from the Elbe). This bedding of paving sand is placed immediately on the natural soil when the latter offers a good and solid foundation (Fig. A). If, however, the street bed is artificial, therefore less resistant, the foundation is strengthened by a layer of coarse quarry stone, upon which the paving sand is then spread (Fig. B). Streets are frequently temporarily paved with coarse quarry stones, which, however, must be cut to fit without leaving too large cracks. These stones are cut into paving stones averaging from 0.18 by 0.2 yards (16 by 19 centimetres) in size. Their broad-

est surface must be plain, but their shape need not be regular; their width should be about 0.13 by 0.19 yards (12 by 17 centimetres), the incline of their sides not exceeding 1 to 5.

The paving stones, when set in the sand layer,* must project about 00.44 yards (4 centimetres) over the intended street surface; they are then beaten down with hand rams of cast iron, weighing 50 kilograms, or partly rolled tight with a steam roller and then rammed. Before this process the cracks between the paving stones must be carefully stopped up with sand and sprinkled with water.

While setting the paving stones a wooden pattern is continually passed over the surface, serving to maintain the exact arched profile of the street.

In order to secure a uniform wear and long resistance of the pavement, as well as a good appearance of the same, care must be taken that all stones used be intact at their edges and corners. Special care is therefore recommended when loading and unloading such stones. It is further recommended that on one tract of pavement the stones should be of equal size and come from the same quarry. If these rules are strictly followed, an unequal wear of the surface of the pavement is almost entirely prevented.

The sand bedding below the completed pavement must be about 0.175 yard (16 centimetres) thick when rough paving stones or third-class stones are used; for a second-class pavement and slag-stone pavement the sand layer must be 0.153 yard (14 centimetres) thick; for a first-class pavement, 0.13 yard (12 centimetres) thick.

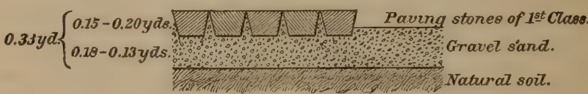


Fig. A.

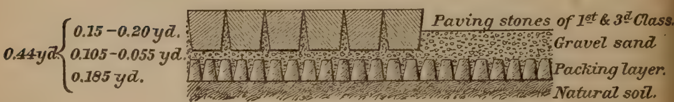


Fig. B.

First-class paving stones are only used in the most fashionable parts of the city, or for such streets on which the traffic is very heavy; third-class stones, for less important streets and centers of squares; second-class stones, for all other streets and for pavement between street-car rails.

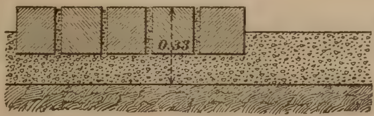
Streets which are newly laid out are at first macadamized, and only provided with a regular stone pavement after houses have been erected on the same. For this reason the original macadamized surface is laid out at a height to serve as foundation to the projected pavement.

* This layer is 0.22 by 0.26 yards (20 by 24 centimetres) thick.

A new kind of paving material—cast slag stones—has been invented during the last 10 years. These slag paving stones are exact cubes, measuring 0.175 yard (16 centimetres) in diameter, and are very solid. Such a pavement is claimed to have an extraordinary resisting capacity and is regular and smooth. Hardly any noise is caused by carriages, etc., on streets paved with slag stones, and it is very easy to keep them clean; slag stones are, therefore, frequently used for sidewalk crossings, and for gutters on macadamized streets.

There are, up to the present date, but few streets paved with slag stones in Dresden, because its durability has as yet not been sufficiently tested.

Slag Stone Pavement.



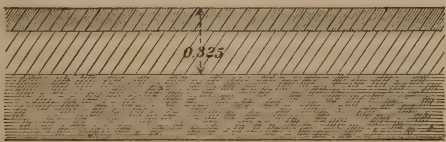
The principal disadvantage of slag-stone pavement is that in course of time it becomes very slippery and offers little hold to horses' hoofs.

Asphalt pavement.—Asphalt is used most extensively for paving streets. The quality used is almost exclusively compressed asphalt. The layer on which the asphalt is spread is prepared as follows: The ground is at first carefully rolled, its level being held at 0.27 yards (25 centimetres) below the projected street surface. On this is spread out a layer of cement concrete, composed of one part of Portland cement, four parts of gravel from the Elbe, and six parts of small broken stones. This layer, when fresh, must be 0.27 yards (25 centimetres) thick; it is then compressed to 0.216 (20 centimetres).

The cement layer must be given sufficient time to thoroughly harden. The hot asphalt is then spread over the cement; the asphalt layer, being at first 0.076 yards (7 centimetres) thick, is rolled down to 0.055 yards (5 centimetres).

The kind of asphalt in principal use comes from Val de France, or Seyssel, and is mixed with Sicilian asphalt in the proportion of 1 to 3.

Asphalt Pavement.



Wood pavement.—In the year 1877 several streets were paved with wood. This wood pavement consisted of paving blocks of pine wood 0.11 yard (10 centimetres) in size. The foundation must be a layer of

concrete 0.216 yard (20 centimetres) thick. The cost of such pavement proved to be 13.80 marks per square yard (17 marks per square metre).* The wood, however, did not offer sufficient resistance, and was replaced by asphalt 6 years later.

In 1887 another attempt was made with oak paving blocks set on a layer of concrete of 0.216 yard (20 centimetres), but the cost of such pavement amounting to 17.14 marks per square yard (20.50 marks per square metre)*—the very cheapest oak costing 15 marks per square yard (18 marks per square metre)—this system was abandoned.

Very recently extensive attempts have been made with beech wood. The single blocks were fastened together with wire, thus forming larger blocks, and were used for paving a temporary street-car line running through the promenades of a projected "ringst vasse" (circular street around the city). Considering the temporary character of this construction, a gravel bedding only was placed below the pavement, a mixture of tar and pitch being poured over the former to protect the pavement against the penetration of dampness. The paving blocks were then set and the cracks filled out with the same mixture of tar and pitch. It has, as yet, been impossible to form an opinion of the durability of this kind of pavement, as it has only been in use for a year.

COST OF STREET CONSTRUCTION.

The cost of constructing the different kinds of streets, as described above, exclusive of the costs of transportation of building material to Dresden, but inclusive of the expenditures for short local transportation within the city were figured during the past year as follows:

Macadamized street having one layer of small broken stone, 0.164 yard thick, and one layer of coarse broken stone 0.219 yard thick, when using finely broken syenite, 3.30 marks per square metre (2.75 marks per square yard); when using Tischlowitz basalt, 3.40 marks per square metre (2.84 marks per square yard); when using Praskowitz basalt, 3.45 marks per square metre (2.88 marks per square yard); when using porphyry, 3.05 marks per square metre (2.55 marks per square yard); when using greenstone, 3.40 marks per square metre (2.84 marks per square yard).

Macadamized street, having one layer of small broken stone, 0.196 yard thick, and one layer of large quarry stones (packing layer) 0.187 yard thick, when using finely broken syenite, 3.15 marks per square metre (2.63 marks per square yard); when using Tischlowitz basalt, 3.30 marks per square metre (2.76 marks per square yard); when using Praskowitz basalt, 3.45 marks per square metre (2.88 marks per square yard); when using porphyry, 2.95 marks per square metre (3.30 marks per square yard); when using greenstone, 3.40 marks per square metre (2.84 marks per square yard).

* The prices for the different kinds of wood pavement include wages, material, etc

Rough pavement on layer of gravel, 4.80 marks per square metre (4.40 marks per square yard).

Dressed (regular) pavement on layer of gravel, using first-class stones, porphyry, granite, and syenite, 9.60 marks per square metre (8 marks per square yard); greenstone, 10.80 marks per square metre (9 marks per square yard). Using second-class stones, porphyry, granite, and syenite, 9.20 marks per square metre (7.70 marks per square yard); greenstone, 10.80 marks per square metre (9 marks per square yard). Using third-class stones, porphyry, granite, and syenite, 8.20 marks per square metre (6.85 marks per square yard); greenstone, 10.80 marks per square metre (9 marks per square yard).

Slag stone pavement on layer of gravel, 6.40 marks per square metre (5.35 marks per square yard).

Dressed (regular) pavement on layer of large quarry stones (packing layer). Using first-class stones, porphyry, granite, and syenite, 10.60 marks per square metre (8.87 marks per square yard); greenstone, 11.80 marks per square metre (9.87 marks per square yard). Using second-class stones, porphyry, granite, and syenite, 10.15 marks per square metre (8.50 marks per square yard); greenstone, 11.80 marks per square metre (9.87 marks per square yard). Using third-class stones, porphyry, granite, and syenite, 9.20 marks per square metre (7.68 marks per square yard); greenstone, 11.80 marks per square metre (9.87 marks per square yard).

Slag stone pavement on layer of coarse quarry stones ("packing layer"), 7 marks per square metre (5.85 marks per square yard).

Asphalt pavement, composed of 0.220 yard (20 centimetres) of concrete, 3.60 marks per square yard (4 30 marks per square metre); 0.053 yard (5 centimetres) of asphalt, 10.60 marks per square yard (12.65 marks per square metre); giving a total of 14.20 marks per square yard (16.95 marks per square metre).

These prices for asphalt pavement were paid to private building companies, who undertook the first construction of asphalt streets in Dresden, giving guaranty for 5 years.

All asphalt pavement is now executed by the government building department and not by private contractors, naturally without guaranty. The costs therefor being reduced by 3.50 marks per square yard (4.20 marks per square metre), thereby giving a total cost of 10.70 marks per square yard (12.75 marks per square metre) for asphalt pavement as above described. It must be further understood that the quotations given for asphalt pavement include all costs of transportation, as it has been impossible to ascertain such costs, delivery being free Dresden.

The preparation and profiling of the natural foundation (substructure) of all street constructions amounts to 0.84 mark per square yard (1 mark per square metre) in average, and is not included in any of the foregoing figures.

In the city of Leipzig, where the paving of the streets is mostly intrusted to private contractors, the costs for the different kinds of pavement during the past year were figured as follows:

Slag stone pavement, 6.20 marks per square yard (7.40 marks per square metre).

Dressed (regular) pavement, first-class stones, 9.13 marks per square yard (10.90 marks per square metre); second-class stones, 8.48 marks per square yard (10.15 marks per square metre); third-class stones, 8.23 marks per square yard (9.85 marks per square metre).

Asphalt pavement, thickness of layers as described above, 13.88 marks per square yard (16.60 marks per square metre).

It will be noted that the costs for paving in Leipzig do not differ very much from those in Dresden. Only slag stone pavement is much less expensive, because the rates for transportation are much lower to Leipzig than to Dresden.

During the year 1889 the "Tieflauamt" (board of substructures) of Dresden showed the following figures:

Kind.	Square yards.	Square metres.
Macadamized streets	6,600	5,500
Dressed (regular) pavement	62,500	52,300
Rough (irregular) pavement	32,400	27,000
Asphalt pavement	7,500	6,300

Seven thousand four hundred and eighty yards (6,850 metres) of sewer, of a medium oval-shaped section measuring 60 centimetres in height and 40 centimetres in width, and 45,600 square yards (38,200 square metres) of sidewalks, constructed partly for public and partly for private use. The total expenditure incurred by the Tiefbauamt during the year 1889 for the above constructions amounted in a round sum to 1,115,000 marks. Since the close of 1889 the cost of material and for wages has considerably increased.

CONSTRUCTION OF SIDEWALKS.

Most of the sidewalks are covered with granite slabs 0.164 yard (15 centimetres) thick, and cost, according to the quality of the stone, from 9.20 marks per square yard (11 marks per square metre) to 10.86 marks per square yard (13 marks per square metre). The cost of laying the slabs, inclusive of expenses for sand and cement (used to fill out the space between each slab) are figured at 92 pfennings per square yard 1.10 marks per square metre). Exceptionally wide sidewalks are paved with a single line of granite slabs, and on each side a "mosaic" pavement composed of small stones is laid.

These "mosaic" stones consist of limestone or of porphyry; they are cubic-shaped, and do not exceed 9 centimetres in size. This pavement costs 3.90 marks per square yards (4.68 marks per square metre).

It is less frequent that the described portions of wide sidewalks are covered with a layer of cement. In such cases the cement layer must be 0.022 yard (2 centimetres) thick and rests on a foundation of concrete 0.145 yard (13 centimetres) thick. Cement slabs 0.065 yard (6 centimetres) thick and 0.38 yards in diameter, resting on a foundation of mortar 0.022 yards (2 centimetres) thick, are also used for sidewalks. Both systems of construction cost 3.90 marks per square yard (4.68 marks per square metre).

An altogether exceptional mode of paving sidewalks consists in the use of ribbed square plates of "Dutch tile" from Meissen, 0.065 yard thick by 0.38 yard in diameter. The foundation consists of a layer of cement, mortar or concrete 0.153 yard thick. The average cost is 6.10 marks per square yard (7.32 marks per square metre.)

The curbstones for sidewalks are mostly of dressed granite. The cost for curbstones, including laying, wages, etc., are: When 0.44 yard wide and 0.22 yard high, 7.90 marks per yard (8.60 marks per metre); when 0.22 yard high and wide, 5.30 marks per yard (5.80 marks per metre).

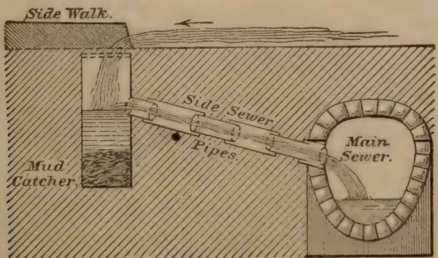
Slag curbstones are also, but not frequently, used, and cost when 0.165 yard wide and 0.22 yard high, 1.38 marks per yard (1.50 marks per metre).

SEWERS.

Every city street must be provided with a means of sewerage and drainage; new streets, when constructed, and before houses are built on the same, must be provided in the same way. These drainages consist of a main sewer located in the center of the street.

Side sewers, 0.165 to 0.22 yard (15 to 20 centimetres) in diameter, serve to conduct the water from the street into the main sewer. These side sewers are made of earthen pipes, and are located 32.7 yards (33 metres) from each other. The sewer openings, serving to lead off the rain water from the surface of the street, are located in the street gutter or form part of the granite curbstone. When located in the street gutter these apertures consist of square iron boxes.

To prevent the mud and dirt from obstructing or stopping up the



sewer pipes, a "mud-catcher" of brickwork, or of iron, is fixed below each aperture, and is 1.10 yards deep by 0.44 yard wide.

Side sewer pipes of same size as above also serve to conduct the rain water from the roofs, as well as the waste water from the houses into the main sewer.

In narrow streets the central sewers are in most cases too small to permit men to pass through for cleaning and repairing purposes. Such sewers are then provided with round vertical manholes, located at an average distance of 32.7 yards from each other, and serve for cleaning as well as draining purposes. These manholes are covered with iron lids, which are coated with asphalt or plated with oak, on asphalt streets, to prevent noise.

Formerly the sewers were constructed of sandstone masonry, cemented with mortar; smaller sewers were constructed of sandstone blocks hollowed out in shape of gutters, and either covered with stone slabs (Fig. 1) or arched (Fig. 2).

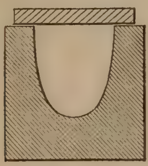


Fig. 1.

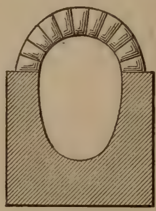


Fig. 2.

At present sewers are universally constructed of cement, mortar, and concrete; sewers of smaller diameter (varying from 0.49 yard in height and 0.33 yard [0.3 metre] in width, to 1.64 yard [1.5 metres] in height, and 1.1 yards [1 metre] in width) are furnished ready for use in one or two pieces of 1 metre (1.1 yards) in length.

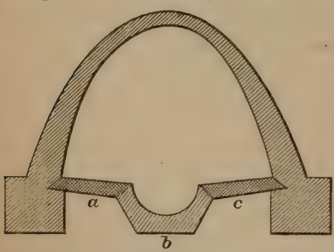


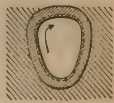
Fig. 3.

Larger sewers of a profile, as shown on the annexed diagram, have a gutter for waste water, and are constructed of stamped concrete, some parts of the foundation blocks (as *a*, *b*, and *c*) being furnished ready shaped for use.

The manholes, as above described, are at present also constructed of stamped concrete, and not of brickwork as heretofore.

The width of the sewers is based upon the following calculation:

$$V = F\sqrt{\frac{\frac{F}{S} \cdot \frac{h}{l}}{0.00015 + \frac{0.0000045.S}{F}}}$$



V = The quantity of water in cubic meters required to be drained per second.

F = The cross section of the sewer in square metres.

S = The interior circumference of the sewer in metres.

$\frac{h}{l}$ = The relative (actual) incline of the sewer.

The quantity of water to be drained per second from 1 hectare (109;6 square yards of area) is assumed to be as per following table:

Description.	Rain water.	Waste water.	Total.
	Cub. met.	*Cub met.*	*Cub. met.*
Densely built	0.05	0.0034	0.0534
Less densely built	.04	.0023	.0423
Single houses (residences)	.03	0004	.0304

The above figures refer to the minimum profile or section of a sewer. All calculations are strictly based upon these figures, even if circumstances rendered a smaller sewer practicable. A rainfall as heavy as 0.02 yard (18 millimetres) per hour, is provided for in the above calculations.

The cost of sewers at a depth of 2 metres, during the past year, was as follows:

Size of sewer. Height.	Size of sewer. Width.	Cost of constructing the sewer channel	Digging and filling up.	Total in marks.	Per 1.1 yard. 1 metre for increased depth of sewer.
Yards.	*Yards.*	*M. pf.*	*M. pf.*	*M. pf.*	*M. pf.*
0.491	0.327	7 40	8 41	15 81	2 65
0.573	0.382	9 23	8 88	18 11	2 83
0.654	0.436	11 40	9 30	20 70	3 10
0.817	0.545	14 40	10 30	24 70	3 33
0.982	0.654	21 15	11 70	32 85	3 61
1.146	0.764	27 65	14 25	41 90	4 47
1.314	0.872	33 90	15 40	49 30	4 75
1.635	1.09	43 75	18 25	62 00	5 40

The cost of a manhole connecting a sewer with the street surface, when the sewer is located at a depth of 2.5 metres, is 105 marks; adding 8 marks for extra work and 37 marks for iron lid, gives a total of 150 marks, in a round sum. Each metre of increased depth 37 marks more. An oak plated lid costs 53 marks instead of 37 marks. The side sewer pipes, when 0.165 to 0.22 yard in diameter, cost, ready-made, including laying and fastening, from 3.10 to 4.02 marks per yard.

Brick mud-catchers provided with iron apertures cost 32.30 marks apiece; solid stone mud-catchers, 35.30 marks apiece, inclusive of all work connected; granite apertures with stone lid cost 44 marks.

APPORTIONMENT OF COSTS—STREET CONSTRUCTION AND REPAIR.

All expenses caused by a reconstruction or total repair of an existing street are paid by the city treasury. New streets, however, are laid out at the cost of the proprietors of the adjacent grounds or houses. To cover the expenses for sewerage such proprietors are required to pay 21 marks per yard (23 marks per metre) of front extension of their premises. For corner grounds the actual length of premises must be increased by the average width of the two adjacent streets.

The costs of primary construction of streets, such as earthworks sewerage, macadamizing, gravel footpaths, in some cases rough pavement, must be borne by the proprietors of adjacent houses or grounds in proportion to the extension of their premises. Street crossings are constructed at the cost of the proprietors of the four corner buildings, These expenses are eventually advanced by the contractors to the landed proprietors, who, temporarily, may not be desirous to pay their share at once, under the condition, however, that such outlays of money be refunded by the proprietors when houses are erected on their premises.

In case such primary construction of a street proves to be a public necessity, therefore, not originating from an application of private persons, the costs must be borne by the city treasury. The money thus expended can, however, later on, be claimed from the landed proprietors, as soon as they begin to build on such streets.

The construction of streets (called "blind alleys") without any communication with other streets is prohibited.

The construction of new streets is only permitted upon submission of plans that must be approved of by the "tiefbauamt" (board of substructures), which then undertakes the building.

It was formerly the duty of the house proprietors to clean street and sidewalk; this is now all done by the city, but to defray the expenses the sum of 2.00 marks per square metre (1.67 marks per square yard) is collected from the house proprietors when the area is ceded to the city for street construction purposes.

The street-car companies are at the present time required to pay the city for cleaning the pavement between their rails, as well as 0.65 yard = 0.6 metre width of pavement outside the rails, at the rate of 8.4 pfennigs per yard (10 pfennigs per metre.) For squares and streets with only one row of houses, as for instance along the river, the proportionate division of the sums collected from the house proprietors to cover the expense of construction and sewerage varies, according to local regulations, between the above mentioned figures and twice as much.

The decision of the "Rath" (city council) is required whenever it appears urgent to pave a macadamized street.

The first pavement, if rough, is also executed at the cost of the adjacent proprietors, and this according to the regulations above mentioned.

If the first pavement consists of dressed, regular, paving stones instead of rough, the surplus expenses as well as all further costs for repair and maintaining, must be borne by the city treasury.

It is considered exceptional when the adjacents desire a superior pavement on their street than the city authorities deem necessary for the local requirements. If such applications are approved of the applicants are held to bear the surplus costs, or to pay a certain sum upon other mutual agreement.

All repairs of streets, when completed, must be undertaken by the city.

Macadamized streets are usually transferred 3 months after they have been opened to the public, for maintenance to the city, so that the parties that originally built the streets are compelled to bear the expense of maintenance during fully 3 months. The reason for this is that a new macadamized street requires unusual attention and care during the first period of its existence. The street-car companies are also held to bear part of the costs for constructing and keeping the streets. The portion of the street constructed and maintained at the cost of these companies consists of the substructure below the rails and the portion between the rails extending to 0.65 yard (0.6 metre) beyond both outside rails.

All sums expended by the city treasury for repair and construction of streets must be approved of by both the "Rath" and the "Stadt verordneten"; on the whole the construction of streets is undertaken upon the petition of those held by law to bear the expenses, the estimated cost being paid by these parties to the city treasury.

The costs for new sidewalks, or for alterations of the same (that may appear necessary through the erection of new buildings) must be borne by the adjacents.

Should the costs for sidewalks exceed the standard estimates the surplus expenditure is borne by the city.

Costs resulting from maintenance or reconstruction of a sidewalk, occurring in case of an alteration in the direction of the street and expenses for widening the same by reason of an increase of traffic, are paid by the city treasury.

Towards the end of the year 1889 the city of Dresden, counting 276,000 inhabitants, possessed within its limits 1,160,000 square yards (970,000 square metres) of paved streets, of which 520,000 square yards (434,000 square metres) were paved with dressed stones, the remaining with rough stones; further, 840,000 square yards (700,000 square metres) of macadamized streets. The maintenance and repair of paved streets caused an expenditure of 46,000 marks during the year 1889, or 4 pfennig per square yard (4.74 pfennigs per square metre). The main-

tenance of the macadamized streets cost in 1889 150,000 marks, or 17.9 pfennig per square yard (21.4 pfennig per square metre).

It should be stated that the above figure for maintaining the macadamized streets includes the maintaining of the gravel sidewalks. An approximate calculation shows that the maintaining of that part of a macadamized street used only by carriages would average 15 pfennig per square yard (18 pfennig per square metre).

Excluded from the above figures is that portion of the streets constructed and maintained by the street-car companies, covering an area of 826,000 square metres (985,000 square yards) of paved surface, and 100,000 square metres (120,000 square yards) of macadamized surface.

The maintenance of the asphalt streets covering an area of 19,000 square metres (22,700 square yards) did not cause any notable expense for the reason that the first asphalt streets had not been constructed by the city, but had been executed by private contractors the latter still having charge of their maintenance.

In addition to this the repair of the sewers in the city of Dresden cost during the year 1889 12,000 marks; their cleaning 25,000 marks; the maintenance of sidewalks and footpaths 3,000 marks; the maintenance of the "Bauhof" (large storage grounds for street material) 2,000 marks, and the repair and renewal of apparatus and tools for street construction purposes 38,000 marks.

At the close of the year 1886 the city of Leipzig, counting 170,000 inhabitants had 486,000 square yards (406,000 square metres) of dressed pavement, 60,000 square yards (50,000 square metres) slag pavement, 360,000 square yards (301,000 square metres) rough pavement, and 14,400 square yards (12,000 square metres) asphalt pavement. The cost of repair and maintenance for these streets was figured during 1886 at 2 pfennig per square yard (2.4 pfennig per square metre) for dressed pavement and 3 pfennig per square yard (3.6 pfennig per square metre) for rough pavement.

In 1883 the expenditure for maintenance amounted to 6.3 pfennig per square metre (5.3 pfennig per square yard), no distinction being observed between dressed and rough pavement. It may therefore be stated that the average expenditure in Leipzig was equal to that in Dresden.

ADMINISTRATION OF STREETS.

The administration and general management of all matters concerning the construction, repair, and maintenance of city streets in Dresden is intrusted to the "Stadt bauamt (city building board), and "Tiefbauamt" (board for substructures). The "Baupolizeiamt" (building police board) has charge of the preparation and drawing of the plans and diagrams, and also of the general regulations for construction with the coöperation of the "Tiefbauamt;" it is further the duty of the "Baupolizeiamt" to grant permits for building and to superintend the erection of private houses.

The duties of the "Stadtbauamt" are the following:

(1) To regulate and settle all legal and financial matters arising with the construction of new streets and their alterations (to an extent not to interfere with the duties of the "Baupolizeiamt"), until the actual construction of the street is undertaken by the "Tiefbauamt," inclusive of the expropriation. (2) To collect the shares of payment from the adjacents for street and sewer construction according to the local laws. (3) To secure guaranties for such payments, and to settle all claims that eventually may arise. (4) To direct and superintend the street police force, partly. (5) To settle all legal matters involved in the public navigable ways within the limits of Dresden, excluding, however, such that refer to the traffic on the river Elbe. (6) To keep the cash account for the city street construction. (7) To control the treasury for city street construction (separate treasury department). (8) To submit opinions upon legal inquiries made by the "Hochbauamt" (board for superstructure), and by the "Tiefbauamt." (9) To submit opinions upon inquiries relating to the publicity of a road or street. (10) To superintend and sell city property, and, on the other hand, to purchase private grounds.

The "Hochbauamt" has nothing to do with the construction of streets.

The duties of the "Tiefbauamt" are the following: (1) To plan and construct streets, sewers, and bridges in cities and towns, including the miscellaneous work, as:

(*a*) Drawing up the documents serving to raise the necessary fund; (*b*) projecting and preparing plans; (*c*) purchase of material; (*d*) insurance against sickness and accidents; (*e*) the mediation of all business transactions between private contractors with the city authorities, or submitting statements of construction and estimates of funds required for the same to the city authorities. (2) To maintain and repair the city streets, sewers, and bridges to the same extent as referred to sub No. 1, and *a* to *e*. (3) To offer technical assistance to the Stadtbauamt and to other administrative departments of the "Stadtrath" (city council), by submitting suggestions, estimates, preparation of plans, etc.

Other works that are executed in the streets, such as the laying of gas and water pipes, and of underground telegraph wires, practically belong to the respective executive departments of the "rath" or to the post-office department, but in all such cases the work and repair of the street is undertaken by the "Tiefbauamt."

The directors of the "Stadtbauamt," the "Baupolizeiamt" and the "Hochbauamt" and "Tiefbauamt" are salaried members of the "Stadtrath" (city council).

These men are academically educated as 2 lawyers, 1 architect, and 1 engineer.

The division of the "Tiefbauamt" may be of interest, as the board is

exclusively intrusted with the technical supervision of the entire street construction system.

The Tiefbauamt is, if not distinctly, practically divided into two departments, one for the interior and the other for the exterior service—preparation and execution of constructions. The first department employs, besides the office clerks, 6 technical men, among whom are 3 studied engineers.

The work in the second department is performed, according to the division of the city district, into, 3 inspections for substructures by 3 inspectors with 3 assistants, 3 substructure surveyors, and 3 substructure guards.

For maintenance of macadamized streets an extra number of 30 road-guards are employed.

The superintending force of the Bauhof (storage ground for materials and tools) with 4 officials forms a separate department, but also stands under the Tiefbauamt.

The Bauhof serves to store away all materials for road and street construction that are not transported for immediate use direct to where the street is being built, such as sand and gravel; some stone is partly prepared for use within the Bauhof. The machines, implements, and tools are also stored there, and, when necessary, repaired. The Bauhof also serves to store away old used building material, provided the same be in good condition, until further use can be made of it.

The administration of the Tiefbauamt in the city of Leipzig is organized in a similar way, with the exception that the head engineer is not a member of the "Rath." The other men employed are, 3 studied engineers and 6 technical employés, 1 street master, 1 surveyor, and 6 guards, the latter three being employed during the construction of works.

In Leipzig the duties of the administrative force are more extended, inasmuch as the "Tiefbauamt" has charge of the city survey (this being in Dresden the duty of the "Baupolizeiamt") and is required to superintend the laying of gas and waterpipes, as well as the maintenance and regulation of the water-ways, the latter being very extended.

The repair of the macadamized streets, on the contrary, belongs to an entirely different branch of the city administration.*

The annual expenditure for salaries and stationery amounts to 25,000 marks for the Stadtbauamt and 71,500 marks for the Tiefbauamt, 14,000 marks being used for the offices, 48,000 marks for the three substructure inspections, and 9,500 marks for the Bauhof (storage grounds).

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* Attention is hereby called to a publication obtainable at all booksellers, entitled: "Organisation der Behörden für die innere Verwaltung" (Organization of the Authorities for the Interior Administration) and to "Die revidirte Städteordnung vom 24. April 1873 (Revised city Regulations of April 24, 1873). These two books contain all desirable information about the organization of the city administration and its divisions.

INFLUENCE OF IMPROVED STREETS ON PROPERTY VALUES.

What influence the construction of a street has on the land value may be best judged from the time when new streets are laid out for the purposes of erecting houses along them.

The ground and the productiveness of the soil increase, under such circumstances, far over ten times in value when compared with the value of an ordinary field or meadow.

Agricultural land becomes practically city lots as soon as the decision of the city authorities to construct a street through it is known, but building can only be begun when the street is completed. The traffic with the center of a city is greatly facilitated when the means of communication consist of solidly built and well kept streets; therefore the land values and the wages for labor increase.

Good roads, as well as railroads and water-ways, form a quick and cheap means of transportation of the necessaries of life from the country to the cities, and therefore may be considered as one of the most important conditions for their prosperity.

It is far easier to keep good streets clean than bad ones.

Therefore, the sanitary condition in medium sized and large cities is greatly dependent upon the system observed in constructing and keeping the streets.

STATE AND COUNTRY ROADS.

In Saxony the highways—state roads as well as country roads—are mostly macadamized.

The surface of the more important and more used roads is strengthened with small broken stones tightly wedged in and rammed down, under which there is a layer of coarse broken stone.

The surface of less important roads is only composed of a layer of small broken stone on gravel or sand; in some cases gravel only is used.

The stones used for the construction and repair of the roads are generally obtained in the closest vicinity, and in this case the best of what can be had is chosen. For some state roads, especially those that are subject to frequent and heavy traffic, the road-building material, which must then be of superior quality, is in part brought from distant quarries; for instance, basalt is brought from Bohemia.

Water-ways (in this case the river Elbe) are, wherever practicable, chosen for the transportation of such material, thereby greatly reducing its cost.

The stone from Bohemia is even transported as far as Leipzig. The kinds of stone principally used for the construction and repair of roads are the following: Syenite (for paving), coarsely grained granite (for paving), finely grained granite (preferred for paving), quartz-slate (used for repair, excellent material but rare), quartz (use very limited), sandstone (use very limited), greenstone (excellent material), porphyry (most *universally* used in Saxony), basalt (is considered the best stone), coarse gravel (screened), pit (mine) gravel, and river sand.

The coarse gravel, cleaned and passed through a screen and broken to an egg size, is used on state roads on which the traffic is light and less frequent, and also to a great extent on country (communication) roads in flat country, when a more adaptable stone material can not be found in the neighborhood.

Pit gravel and river sand are used for covering the road surface, and serve as a joining material when the smaller broken stone layer is rolled tight. Where sand is not obtainable finely pulverized stones, slags, and sandy loam may be used for this purpose.

All the stone materials as enumerated above are obtained by the Government board for road construction partly from the Government quarries, the latter being leased to private contractors for the purpose of breaking and transporting the stone, and partly from quarries owned by other parties against payment of interest.

In frequent cases contracts are made by the board of road construction with these owners of quarries or with other private contractors to deliver the coarse broken stone and the small broken stone ready for use to the place of construction or, at least, to the nearest railroad station. (This refers to Bohemian basalt transported to Dresden or Leipzig.) The price of such material varies according to its value, to the greater or smaller difficulties encountered in the quarry where obtained, and to the distance of transportation.

The price for coarse stones from the quarry vary from 2.30 to 9.20 marks per 1 cubic yard (3 to 12 marks per cubic metre) and for small broken stone from 3.80 to 13.80 per cubic yard (5 to 18 marks per cubic metre), including the costs of transportation to the place where the material is used.

The average price may be fixed: For coarse broken stone and small broken stone at 4.60 to 6.10 marks per cubic yard (6 to 8 marks per cubic metre).* Coarse gravel costs about 2.30 marks per cubic yard (3 marks per cubic metre).

The rock substructure foundation or packing layer, on which is spread the layer of small broken stone, may consist of softer stone, but in all cases it must resist the effects of frost.

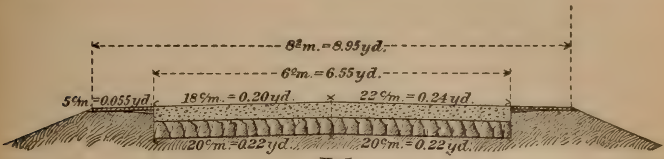
A still softer stone is used, and its price amounts to 3.80 marks per cubic yard (5 marks per cubic metre). The costs for road construction vary according to whether high-priced or low priced material is used, further to the general local conditions, and to whether the road be intended for heavy or light traffic, and finally to the width of the road surface. The costs of maintenance and repair are greatly influenced by the frequency and the weight of traffic.

The width of the state roads varies between 7.7 and 11 yards (7 and 10 metres), giving an average of 9 yards (8.2 metres). The following two diagrams illustrate the heaviest and lightest system of road

* These stones are only broken by hand with iron hammers; stone-breaking machines have been tried, but without satisfactory result.

building all constructions showing different figures are classed between these two.

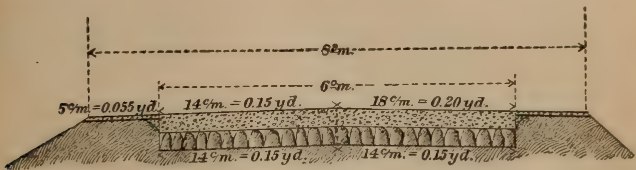
The costs for the heavier construction, which, however, is less frequent, as illustrated in diagram No. 1, are calculated at 27.43 marks



No. 1.

per yard, medium width.

The cost for the lighter construction, as shown in diagram No. 2, is



No. 2.

20.07 marks per yard, medium width.

The above two figures may be specified as follows:

	Marks.
1 cubic metre of coarse stone, for delivery from quarry, to be broken up	6.00
Piling up in regular heaps along the side of road	0.30
Breaking stone	2.20
Spreading stone and covering with sand	0.60
Sprinkling with water and rolling tight	1.30
Total cost for 1 cubic metre	10.40

Now 1 square metre of road surface requires 0.22 cubic metres of small broken stone, 0.22 cubic metres of coarse broken stone (for packing layer), and 0.08 cubic metres of sand. Whereas:

	Marks.
0.22 cubic metre of small broken stones delivered and ready for use at 10.40 marks	2.29
0.22 cubic metre of coarse quarry stones (packing layer), delivery and measuring, at 5.30 marks	1.17
For grading 1 square metre of surface and setting the coarse or packing stones	0.44
For delivering and measuring 0.08 cubic metre of sand	0.26
For supervision of construction, wages, insurance, etc	0.84
Total cost for 1 square metre of road	5.00

One square yard of road, heavy construction, would therefore cost 4.18 marks.

The lighter system of construction would require per square metre 0.18 cubic metre of small broken stone and 0.16 cubic metre of coarse stones (packing layer) and 0.26 cubic metre of sand, the total cost thereby being 3.34 marks per square yard (4 marks per square metre), based upon the same calculation.

These prices, as above referred to, include costs of transportation. The average distance of transportation of the materials to the places of construction may be figured for roads in Saxony at about 12 kilometres = 13,000 yards, and the costs for such distance, when transportation is operated by teams (which is mostly the case), would average at 4 marks per cubic meter (3 marks per cubic yard), inclusive of loading and unloading. The sand for covering the stone layers is brought from the nearest vicinity as possible—average distance being 3 kilometres (3,300 yards), and costing 1.50 per cubic metre (1.15 marks per cubic yard), including loading and unloading.

After deducting such expenses for transportation of material and sand the total cost for construction of roads would be: For stronger construction, 19 marks per yard, and for lighter construction 13.30 marks per yard.

CONSTRUCTION OF STATE ROADS (LIGHT AND HEAVY SYSTEM).

With reference to the above figures state roads are constructed as per the following details:

As soon as the road body has been drained, prepared, and profiled, carefully smoothened and graded according to the desired level and width, the large stones for the "packing layer" and the small broken stones are brought to the place of construction.

These stones are piled up on both sides of the road in such quantities as may seem sufficient for the thickness of the different layers; the small stones are then broken into pieces of as near cubic size as possible, measuring 0.066 yard (6 centimetres), the other materials, as sand, gravel, and slag, are in the meantime carried to the place for use. The road bed, which, as above stated, has been carefully graded and smoothened, is rolled tight and rammed, and then the coarse packing stones are set in the same manner as described in the beginning of this report. (See Macadamized city streets.) The completed "packing layer" must form a solid and resisting stone body, equally thick and perfectly smooth on its surface.

To secure quicker drainage of the road bed in cases when the soil below the "packing layer" does not permit the water to soak in, transverse trenches 20 centimetres wide and 15 centimetres deep are dug beneath the packing layer at intervals of 11 yards (10 metres) and are filled up with loose stone and gravel. These trenches conduct the water out of the road bed into the side ditches.

A good drainage of a road and its substructure is the principal condition for an effective and cheap maintenance of a macadamized road.

Wherever practicable all roads should be higher than the level ground, and the side ditches should be at least 0.55 yard deep by 0.44 yard ground width.

Old state roads, in regions where stone is scarce, are often not provided with a packing layer, the layer of small broken stone having been simply spread over the old gravel surface. Such roads, when carefully and continually repaired, may stand the heavy traffic in dry weather, especially in winter, but in spring they become very soft, and, when drainage is unsatisfactory, they often turn into swamps and are altogether impassable.

The packing layer being completed, a layer of small broken stones that have been passed through a screen, is spread over the former, thus forming the superstructure. The whole is then again rolled tight with steam or horse rollers, without the use of water.

The last covering consists of sand and gravel, which, while continually soaked with water, is again compacted with the rollers. The road is then complete and its surface must be entirely smooth and solid, so that not one stone can easily be torn out or displaced.

New macadamized roads are always a little soft until they have had time to dry out completely; therefore, in the beginning, after they have been opened to public use, the road surveyors must carefully watch that all formations of ruts be prevented.

The quantity of water required to soak the road surface during the process of rolling varies greatly according to dry or wet weather, to the condition of the ground foundation, the thickness of the stone layers, and the quality of stone and of covering material used. A steam roller weighing 10,000 kilograms can compact 40 to 60 cubic metres of small broken stone in about 10 hours, two watering carts, each drawn by two horses, being constantly at work.

While constructing and rolling new roads the engineers must see that the original arched profile of the road surface be maintained, its highest elevation being from one-sixtieth to one-fortieth of the width of the road.

Roads on very flat country, constructed with inferior material and not kept very carefully, this referring especially to country (communication) roads, must be more arched than state roads.

Country roads subject to heavy traffic should have a stone bedding (packing layer and macadamized surface) 0.29 yard (26 centimetres) thick, when the stone used is soft, and 0.22 yard (20 centimetres) thick when the material is hard, whereas on country roads with but little traffic the layer need only be from 0.22 to 0.17 yard (20 to 15 centimetres) thick.

On roads with light traffic a layer of coarse broken stone can replace the packing layer, these stones being cubic shaped not exceeding 0.08 yards in size. The small broken stones are then placed on this layer. The incline of important roads on level country must not exceed 1 in

40, in mountainous regions not 1 in 12 to 1 in 15; on the other hand, it is not advisable to construct entirely horizontal roads on account of their drainage.

The carriage road being completed, both the sides, of which one serves as footpath, the other being reserved for the storage of repairing materials, are covered with a gravel layer from 1.1 to 1.6 yards (1 to 1.5 metres) in width, and 0.055 yard (5 centimetres) thick, and rolled tight. The costs for this work are averaged at about 36 pfennigs per square yard (40 pfennigs per square metre).

ROAD TREES.

In order to mark out the border of the roads and make it discernible at night, also after snowdrifts to warn the public against the embankments or other danger, trees are planted along all public roads. This is a prescription of the law and must be strictly adhered to.*

Fruit trees such as apple, cherry, pear, and plum trees are preferred and are planted in flat as well as in hilly country, wherever the climate and local conditions permit such trees to grow. The trees are planted at a distance of 6.6 to 11 yards (6 to 10 metres) from each other. The keeping and nursing of road trees is intrusted to the road surveyors. These fruit trees are leased, and at times yield a crop worth 100,000 marks and more per annum. The costs for planting a road with grafted fruit trees averages, at 0.76 mark per yard 0.80 mark per metre; with wild trees, 46 pfennigs per yard (50 pfennigs per metre).

As an addition to the foregoing paragraph on "costs for road construction," it may be well to state that it is impossible to give the exact cost of the preparation of the road body, as this depends entirely upon the local conditions; but in flat country, where the principal work consists in digging the side ditches and strengthening the slope of the ditches and the border of the road by sowing or patching with grass, the average cost for such works would be figured at 1.65 marks per square yard of road (1.80 marks per metre).

MAINTENANCE AND REPAIR OF STATE AND COUNTRY ROADS.

The maintenance and repair of state and country roads consists principally in the renewal of the surface (superstructure) that has been deteriorated and worn off by the action of the weather and the traffic.

For this purpose the roads are, at certain intervals from 3 to 15 years, according to the frequency of traffic, local conditions and climate, covered with a massive layer of small broken stone which is thoroughly rolled with steam-rollers, as already described. This layer of small broken stone must be 0.16 yards (15 centimetres) thick, and the stone used must not exceed 0.05 yards in size, thus being smaller than for new roads. The total length of all state roads in Saxon is figured at

* There are but few fences or hedges along the roads or dividing fields, in Saxony.

4,050,000 yards (3,703 kilometres), of which 31,000 yards (28 kilometres) are paved, the rest macadamized. Only about one-eighth of this entire length is covered with a fresh layer of stone material during the course of a year. On all other roads very little repairing is required. Per 1,000 yards of all macadamized roads, 43 cubic metres of small broken stone and 13 cubic metres of covering material (sand, gravel) are used, in average, per annum.

The quantity of such material used on single tracts of road, however, is very irregular, and varies, according to the wear and tear, from 18 to 170 cubic metres per 1,000 yards. Besides the regularly repeated general repairs by covering the entire surface of the road with a massive layer of broken stone, local repairs are continually necessary, as filling out ruts and depressions with small broken stones, which serves to keep the road surface comparatively even until the time for the general repair.

Such local repairs are made mostly during the rainy season, when the ruts and depressions fill up with water and interfere with the traffic. The stones used are small, about 0.03 yard (0.04 centimetres) in size, and after spreading they are covered with sand and gravel and rolled tight.

The further consolidation of such repaired spots is then left to the traffic, teams and vehicles being, on such repaired tracts of roads, ordered to pass over that portion of the road.

It is the duty of the road surveyors, together with the road laborers, to keep the surface of the road scrupulously clean. The dust and mud is swept and scraped off the road surface by means of hand-scrapers, brooms, etc., and deposited in piles along the side of the road, and then collected in carts and carried away.

Larger apparatus for cleaning purposes (revolving cylindrical street sweepers), drawn by horses, are only used in the vicinity of cities.

The guards and road laborers, above referred to, must also keep the ditches in good operating condition; they must further take good care of the road trees.

In winter they must shovel the snow off the road, so as to keep a track open for traffic. The roadguards are permitted to exercise, to a certain extent, the duties of the road police service, in order to facilitate the traffic and protect the roads, as prescribed by the regulations referring thereto.

It will not be necessary to refer in detail to the paved tracts of state roads, as this would only be a repetition of what has been said about paved city streets.

MAINTENANCE OF STATE ROADS.

The costs for maintaining the entire length of state roads in the Kingdom of Saxony, viz, 4,050,000 yards, averaged during the years 1880 to 1885 52 pfennigs per yard of road per annum, of which 48 pfennigs

was for the maintenance of the entire road surface (including foot-paths); .015 pfennig for repair of structures; .02 pfennig for the nursing of the road trees, and .005 pfennig for miscellaneous expenses.

These costs have, since 1885, increased to .55 pfennig per yard.

The expenditure for salaries and clothing of the road guards was figured during the said years at .145 pfennig per yard, and 3 pfennigs per yard for official roadmasters and surveyors.

The building of state roads, as well as the construction of navigable ways and the building of houses and railroads, are under the supervision of the third department of the "Royal finanz ministerium" (treasury department). A special technical director for road-building is attached to this department.

There are in Saxony 17 districts for the supervision of roads and water ways, embracing usually two "amtshauptmanuschaften" each. The duties of the directors of these districts are to draw up the plans for and supervise the construction of the state roads and of the navigable ways, and also to attend to all technical matters connected therewith. They are supplied, as the case may require, with a number of engineers and government architects.

Saxony is further divided into 76 road-master districts, so that from 4 to 5 road masters stand under each district surveying director. These road officials must survey and conduct the works for road repair, and are intrusted with the control of all the road guards, 811 in number, throughout the entire Kingdom of Saxony.

The road guards have from 3,000 to 7,000 yards of road (in average about 6,000 yards) each to repair, clean, and survey; in case of necessity one or two day laborers are placed at their disposal for assistance.

When a general repair of a road is undertaken, with the use of a steam roller, fifteen to twenty extra men are required for such work, so that the repair be completed within the shortest possible time. In such cases several divisions of road laborers and road guards are temporarily called together and are superintended by a road master.

In case of construction of a new road the road guards and road masters must promptly report when called upon.

All treasury matters are handled by the department, which is entirely separate from the technical department. This department, called "bauverwaltereien," whose directors recently are mostly custom officials, handles also the treasury matters for public buildings and water constructions.

The police service on the roads is executed by the amtshauptmannschaften, the latter forming part of the department of the interior. They superintend the entire rural police force, and are consequently the superior authority to the road masters and road guards, who, with the assistance of the other police officials, perform the duties of the road police service.

Considering that the duties of the different administrative depart-

ments are so closely connected with each other, it is not possible to state the exact sum expended for the supervision of state roads separately, therefore only the following figures can be given:

The present annual sum expended for the use of the "finanz ministerium" (ministery of finances), including offices, stationery, main cash and paying office, bookkeeping, accounts and calculations, may be stated as being 2,000,000 marks in a round sum, and the average annual expense for the use of the administration of road and waterway construction, 4,814,000 marks in a round sum. The latter sum embraces all costs for maintenance of roads, bridges, and other structures, expense incurred by regulating the river Elbe, and also the following detailed expenses:

	Marks.
Salaries:	
Academically studied officials:	
2 technical "Baurathe" (members of the board for public construction) at 6,600 marks each per annum	13,200.00
19 inspectors for roads and navigable ways at 3,300 to 4,800 marks; 19 government architects and assistant architects, at 2,100 to 3,000 marks	122,200.00
Inferior officials:	
76 roadmasters (for building and maintenance), at 1,500 to 1,800 marks	151,900.00
811 road guards at 660 to 720 marks	546,400.00
Technical assistants:	
Assistants for technical works and roadmaster candidates	19,000.00
	852,700.00
Special compensations:	
For clothing the inferior officials	62,300.00
Miscellaneous extra expenses	9,100.00
Gratifications	8,400.00
Contribution to protection fund	103,700.00
Other assistance	49,000.00
Hospital taxes, insurance against accidents and old age	16,000.00
Expenses for service, day wages, and traveling expenses	122,000.00
Miscellaneous petty expenses	20,000.00
Removing of snow	170,000.00
Correction and new constructions of roads and bridges	805,000.00
Total	2,218,200.00

Costs for maintenance of roads and planting of trees amounted to 2,210,200 marks.

Sum paid to the bauverwaltereien (offices in the departments), 91,500 marks.

All country roads, as prescribed by the law of January 12, 1870, must have a width of 5.5 yards (5 metres) in open country, and of 7.6 yards (7 metres) within villages and small towns. The width of the macadamized portions of country roads if, as above stated, their total width is 5.5 yards, would be about 4 yards, or 3.6 metres.

The costs of construction of country roads having a stone bedding as

above described, would average both for light and heavy traffic from 10 to 7 marks per running yard. All roads within villages and smaller towns are under the supervision of the magistrate and common day laborers are employed for their maintenance. The average wages of a road laborer may be figured at 2.50 to 4 marks per day within Dresden and other large cities. In the country, where living expenses are lower, the laborers do not get more than 2 to 3 marks per day.

In some cases the supervision of country roads within villages and their repair is transferred, against extra remuneration, to the road masters of the respective districts. Such road masters must be officially authorized for this purpose.

In second instance the country roads are surveyed by the amtshauptmannschaften, that is to say, by their police forces and road masters. In single cases, however, the parishes of an amtshauptmannschaft (*i. e. Dippoldiswalda*) will unite to one corporation for the purpose of mutually maintaining their roads. Such work of repair, etc., is done by special road guards, and also in part by day laborers. The costs therefor are borne by the parishes. All the state roads, however, are maintained at the cost of the general government.

The toll on state roads was suspended 4 years ago, as the revenue did not represent one-tenth of the funds required. A very few parishes contribute small sums of money or provide road-building material, this being in single cases prescribed by an old law.

There are no special taxes for road building and repairing; the funds required are taken from the total revenue of the state.

A special provision of the law prescribes that the parishes must supply the necessary laborers for removing the snow from state as well as country roads on their entire width if practicable. The country roads are maintained at the cost of the town and village parishes and of the independent manor holders.

In small villages it occurs quite frequently that the costs of repair are borne entirely by the "altgemeinden" (old communities). These altgemeinden were composed of a number of owners of old farms that had existed before the building of the village, while all later farm owners and tenants are exempt from such duties.

Persons that make an exceptionally frequent use of a public road, such as owners of quarries, mines, and brick factories, using their own teams for transportation purposes, can be held by the law to bear the expense of maintenance and keeping of such portion of road.

Poor communities, which, according to local circumstances (such as communication to railroads) are subject to considerable costs of maintenance of their roads, are supported with funds by the amtshauptmannschaft or by the state's treasury.

In such cases also the costs of communication roads that are being newly built or improved by reason of an increase of traffic, are partly or wholly borne by the state's treasury. The communities are gener-

ally held to deliver building material and the necessary land without compensation. Such roads when completed are turned over to the communities (parishes) for maintenance.

The principal advantage that is offered by a good and well built road consists in the possibility of transporting considerable loads at a comparative moderate expense. This fact naturally extends the market and increases the prices of all agricultural and mining products, such as stone, coal, brick, etc.

It must be admitted, however, that on one hand the importance of the principal roads, serving for through traffic, has been seriously if not entirely destroyed by the railroads; yet, on the other hand, because of the rapid increase of population, the traffic on the roads that connect one or more small villages or towns shows a decided increase.

Even at present most of the agricultural products are transported by teams over distances exceeding 20,000 yards without the use of the railroads.

Further, all country roads serving as communication to the railroad stations are of great importance, because the transportation of freight by rail is more or less dependent on the road traffic. Higher prices of all products naturally cause an increase of the land value, which, however, in the country is not as apparent as in cities.

The country roads, as well as other means of transportation and communication, represent an important part of the foundation for the welfare and civilization of a nation.

A comparison between the costs of city streets and country roads can only be made in reference to macadamized roads. The costs of construction of both do not differ very much.

A macadamized city street costs on an average about 3.76 per square yards, whereas the two kinds of macadamized country roads average 3.26 marks.

The difference is not great, and is explained by the fact that the wages within a city are considerably higher than in the country. It is different, however, with the costs of maintenance. In Dresden the average annual cost for maintenance of one square yard of street amounts to 15 pfennigs. On government roads, however, the costs of maintenance of one running yard, inclusive of wages of road guards of 62.5 pfennigs on 6,546 yards width of road, amount to 9.55 pfennigs per square yard.

This great difference of costs may be explained, firstly, by the fact that the traffic on country roads is by far inferior to that in the cities. Secondly, besides the above-mentioned difference of wages on country roads and in city streets, it may be stated that the materials for maintaining and repairing the country roads are by degrees during the winter stored along the side of the roads, and prepared for use (breaking and screening). Under such circumstances laborers and drivers can be obtained at much cheaper wages. Thirdly, the material for re-

pair is, for country roads, taken from the nearest neighborhood, while in cities it is stored away in the storage grounds, to which it must be transported from considerable distance. The three points as enumerated give, undoubtedly, sufficient explanation for the large difference in the costs between maintenance of country roads and of city streets.

Regarding the use of the roads it has already been said in the beginning of this report that the roads are open to traffic of every description. This practically is the case, but there are a few restrictions to this general rule, which it may be well to mention.

Powder and other explosive materials can only be transported under special instructions and in special wagons, and such transports must be escorted by police officials. (Acts of the Department of the Interior dated November 3, 1879, November 22, 1884, and December 23, 1885.)

The transportation of road locomotives, steam rollers, etc., is also subject to special regulations (acts of June 9, 1860, and September 26, 1883). For such transportation a permission from the police authorities must be obtained, and an escort of road guards is required. For transportation of long logs of wood or planks, the act of July 9, 1872, prescribes that, besides the driver, such team be accompanied by a second individual, who must properly guide the rear truck.

The act of April 16, 1840, prescribes that teams for heavy loads, such as coal, bricks, earth and stones, must have a width of tire of at least 10½ centimeters (.115 yard). The same act provides that all vehicles must have a flat and not rounded surface of tire. Wagons with nails or other fastening parts protuding from their tires are not allowed to enter the road at all.

The same law provides that all light vehicles (transportation of persons) must have a width of tire of at least .073 (6.5 centimeters) yard. The greatest pressure of the wheel on the road surface must not exceed, for heavy wagons, 2,500 kilograms in summer and 3,000 kilograms in winter, excepting for transportation of loads that can not be divided (like steam boilers, trunks of trees, etc.).

The stadträthe (town councillors) and the amtshauptmannschaften have the right, according to the law of July 9, 1872, referring to traffic on public roads, to issue special rules on certain roads in certain districts for the protection of the traffic; they can also direct certain vehicles to pass on certain roads. Very little use is made of this law.

Wagons that exceed 8,500 kilograms, inclusive of weight of the wagon itself, are not permitted to pass over older wooden bridges.

The same law provides that the width of a loaded wagon must not exceed 2.8 metres, that is to say the load must not extend beyond such width. In exceptional cases a special permission from the police authorities is necessary.

In conclusion, attention is called to the following books issued by the Government and published in Leipzig, and obtainable at the Rossberger-'sche Verlagsbuchhandlung:

"Die Gesetzgebung über Wegebau und Expropriation im Königreich Sachsen" (the legislation concerning road building and expropriation in the kingdom of Saxony), by Ludwig Wolf. This book contains all the rules and regulations regarding the traffic on roads and the manner of the execution of such laws.

Uebersicht der im Königreich Sachsen zur Chaussée Unterhaltung verwendeten Gesteinsarten, Dresden, 1869. (Tabular statement of all the species of stones used for maintenance of roads in the kingdom of Saxony.) This book contains exact information regarding the origin and qualities of road-building material used in Saxony.

Die Organisation der Behörden für die innere Verwaltung vom 21. April 1873 (the organization of the authorities for the interior administration), and, "Revidirte Städteordnung, bez. Revidirte Landgemeindeordnung" (revised city regulations and revised regulations for country parishes), containing all laws and regulations regarding the administration of country roads. The latter two books have been referred to in a previous part of this report.

AULICK PALMER,
Consul.

UNITED STATES CONSULATE,
Dresden, June 29, 1891.

STETTIN DISTRICT.

REPORT BY CONSUL KELLOGG.

STREETS OF STETTIN.

The streets of Stettin (116,000 inhabitants) up to some years ago were mostly paved with common paving stones obtained from erratic bowlders irregularly cut with a flat head, the price of which when set was about 14 to 15 marks per square metre.

In the last five years Stettin, following the wake of Berlin, and the other large cities, has commenced to pave her streets with better material, introducing straight rows of stones instead of curved and broken ones of former years. The city authorities intend, as far as the budget will allow, to have at no distant date the side as well as the main streets well paved with the best material.

The inland quarries not being able to compete with those of Sweden, the best paving stones are hence imported from that country, and especially from the quarries at Carlskaona, Carlshanon, Westerwyk, and Warboy. The Swedish granite is very solid and of fine grain.

The prices of the above stones delivered on the wharfs of Stettin range from 8.50 to 9 marks per square metre.

The granite plates for sidewalks are imported from Christiania and Draunuen, in Norway. The Norwegian granite is of rougher grain,

hard, but splitting easy and well adapted for sidewalk plates. The border and gutter stones are also worked from this variety of granite.

Delivered on the wharfs of the town of Stettin the prices for these materials are as follows:

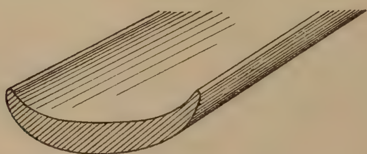
	Marks.
One square metre of granite plates for sidewalks	9.00
One metre in length of granite border stones for sidewalks	4.00
One metre in length of granite gutter stones for sidewalks	2.25

The streets of Stettin, paved with stone blocks as they are, are well adapted for light and heavy traffic. In streets with a declivity of 1 in 100 and less experiments have been made with asphalt pavement 0.05 metre thick, being laid on a granite Beton 0.30 metre thick, under which is a gravel bed 0.20 metre thick. The asphalt paving, including a guaranty of 20 years, costs 14 to 16 marks per square metre.

Best block pavement costs 11 marks per square metre; ordinary block pavement costs 5 marks per square metre; sidewalk pavement (granite plates) 11 to 12 marks per square metre. The cost of keeping the streets in good condition depends upon the amount of traffic.

Formerly the sidewalks consisted of only one line of granite plates about 1 metre wide, and many such walks are still to be found, especially in the older parts of the town; where, however, the streets are well paved with the above-described material the walks are laid out entirely with granite plates.

The edges of the sidewalks were formerly provided with granite gutter stones having in profile the following appearance:



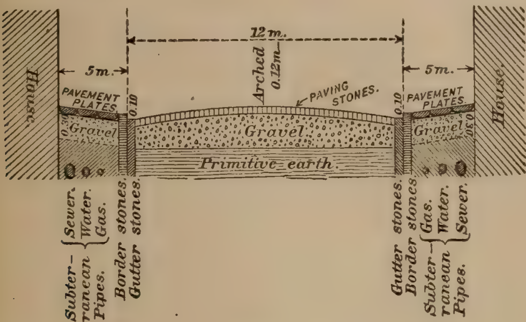
They are now replaced by square granite stones with flat tops laid against the granite border stones at the side of the granite sidewalk plates.

As a foundation for the best paving stones a composite of gravel 0.30 metres thick is employed; for the sidewalk plates a layer of sand is used. After the plates are laid the edges and fissures are cemented with Portland cement.

For keeping the streets in good repair 1 metre quadrannually is reckoned for each square metre of pavement to be provided for from the budget of the city government, whilst property owners are charged an extra amount to keep the sidewalks in good condition or to alter them into the new system.

The expense of cleaning the streets, carrying off dirt, etc., is paid out of a special tax fund, 15 pfennigs per square metre yearly.

Every property holder is compelled to have his sidewalks swept every morning; in the hot summer months they must be sprinkled several times a day, and in the winter season the snow must be swept from the walks, the property holders also having to sweep the snow from the middle of the streets to the sides, and in piles, which must then be carted away. This expense is borne by the property holders. The expense of carting snow away from public places is borne by the people in general, the city authorities generally giving the contract to the lowest bidder.



LONGITUDINAL CUT OF A STREET ETC.

New streets are laid out at the expense of the property holders whose property touches the projected street, who are required to keep them in good condition for four years. After this period the city takes the responsibility of keeping them.

Old streets are preserved and kept in repair by the city alone.

COUNTRY ROADS.

To promote the laying out of high roads and country roads, and keep them in good condition and repair, the budget of the different provinces of Prussia grants a certain sum every year, amounting in the province of Pomerania, of which Stettin is the chief town, to about 400,000 marks ($100,000).

Those counties (kreise) undertaking to construct roads obtain, when the proposed roads are considered a necessity, an allowance of $33\frac{1}{3}$ per cent. of the cost of "à fond perdu," $16\frac{2}{3}$ to 25 per cent. of the cost to be collected by the county itself, but the remaining 50 to $41\frac{2}{3}$ has to be paid by the adjacent property holders, who, however, are reimbursed partly for this by being paid for the assistance they lend in constructing the roads, such as carting sand, gravel, stones, and other material. The adjacents—such as large or small farmers, country towns, or manufacturers, etc.—have to contribute in proportion to the benefits accruing thereby.

If a county has very heavy expenses to meet, such as those accruing from the construction of public works, as high roads and local railroads, etc., it is entitled to issue bonds at a fixed rate of interest, all these bonds to be called in in about 25 years. Each year a certain number of them are canceled, which have been drawn by lot.

The immediate counties of the consular district of Stettin (the counties of Stettin and Randor) have as yet not issued any bonds, but they will soon be compelled to do so as a new local railroad has just been projected.

All high roads and country roads are constructed either with block stones or macadam, the latter being consolidated on top with pounded stone or gravel. The construction of roads is left to the county and district communities, but rarely to a single community or estate.

The system of construction to be followed depends upon the existence of the material, such as stone, gravel, sand, and upon the condition of the soil over which the road is to be built. As there are no quarries in this consular district, the stone has to be dug out and gathered from the fields or procured from other places by water.

The administration of the roads and their preservation falls upon the authorities of the different counties, the president of their boards being the county counsellor (landrath), who, as regards the road, is assisted by the county architect, the inspector of highways, and the guards of the high roads, who are paid by the county. The expense of laying out new roads, paved with block stone, which is partly borne by the provincial government, which also surveys the whole road, varies from 8 to 20 marks per running metre.

The construction of new roads has always been followed by increased benefits to the farmer as well as to the manufacturer, for it gives them increased facilities for bringing their products and wares to market.

In 1875 the administration and preservation of the roads were handed over to the provincial board, but it has since been transferred to the county board of administrators.

From the accompanying cuts one will see that the roads are built with two objects in view, viz, for heavy and light traffic, and teams accordingly choose that part of the road over which, according to the loads they carry, they must drive.

The foundation beds of these roads consist of unhewn stones 0.20 metre thick, covered with granite pieces 0.25 metre in thickness. The upper part of this covering, 0.05 metre, is composed of small pounded stone covered with a layer of gravel 0.03 metre thick.

The whole is rolled several times with heavy steam-rollers.

JAMES KELLOGG,
Consul.

UNITED STATES CONSULATE,
Stettin, January 22, 1891.

ITALY.

REPORT BY CONSUL JONES, OF MESSINA.

COUNTRY ROADS OR HIGHWAYS.

In Italy the minister of public works sees to the laying out, making, repairing, and police supervision of the national, provincial, communal, and vicerial highways.

Carriageable roads are divided into national, provincial, communal, and vicerial roads.

National roads.—Those which connect the chief cities of the kingdom with each other and with the seaports; the magnificent roads across the Alps and Apennines; and military roads, solely for strategic use. When two cities become united by a railway their national road becomes a provincial road.

Provincial roads.—Those which connect the capitals of different provinces; those which connect the capitals of the respective provinces with the seats of the several districts into which the provinces may be divided; and those which connect the capitals of the provinces and the seats of the several districts with the nearest ports.

Communal roads.—Those which connect the county seats with the other towns in their districts; those which run through villages; and those which run from the county seats to the parish churches, cemeteries, railroads. All other public roads are vicerial roads, and are kept up by the communal authorities.

Ownership.—The land used for national roads is government property; the provincial roads belong to the provinces; communal roads to the communes. The public squares in cities and villages form part of the communal highways. National and provincial roads within the limits of a city or village belong to the communal highways.

Construction.—The government builds and keeps up the national highways. Tolls on these roads have been abolished, except on ferries and floating bridges. The cost of building and keeping up provincial highways devolves upon the provinces, which may levy tolls by royal decree. Provinces may also levy a per capita road tax. In the province of Messina this tax is 4 francs, or 80 cents, or 3 days' work on the roads, per annum and per head. The cost of building and keeping up communal highways devolves upon the respective communes; these expenses are paid out of the communal revenues or by a special tax levied by the communes. The communes have the right to establish tolls, which, however, must be abolished as soon as they shall have realized the cost of the road. The keeping up of such portions of national and provincial roads as pass through a city or village falls upon the commune, the government or province paying over annually to said commune a sum equal to the cost of keeping in repair a stretch of road of equal length near the city or village. National, provincial,

and communal roads are invariably macadamized. A roadbed 20 centimetres (nearly 8 inches) deep is dug out and filled in with broken stones, which, after being well watered, are packed down by means of a heavy roller; a layer of earth of sandy or calcareous character is then added, and when thoroughly rolled is well watered and again rolled until the surface becomes firm and smooth.

The width of national and provincial roads is 8 metres (say 26 feet); the average cost per kilometre 30,000 francs or $6,000. The width of the communal road in 5 metres; average cost per kilometre, 20,000 francs or $4,000. The soil in this district is mostly clay, and a deep foundation is not necessary for a good roadbed.

WALLACE S. JONES,
Consul.

UNITED STATES CONSULATE,
Messina, January 26, 1891.

BOLOGNA.

REPORT BY CONSULAR AGENT GARDINI.

The prevailing method employed in making city streets, at Bologna, and other towns, is the union of flint stones on a bed of sand or on a foundation of sifted gravel.

In many of the principal streets of Bologna, at each side, are placed two bands of granite 0.60 metre of breadth, and 0.20 metre of depth, at the distance of 0.60 metre, in order to facilitate the transit of vehicles.

Flint stones are of elyssoidal form; their thickness varies from 0.09 metre to 0.12 metre; most of them come from the river Reno, and a part from the river Adige; the sand is all taken from the Reno.

The pavement made with flint stones of the Reno, on a bed of sand, including the necessary digging, at the depth of 0.15 metre, costs 1.30 lira per square metre.

The same pavement on a bed of 0.15 metre of sifted gravel, including the necessary digging, at the depth of 0.30 metre, costs 2 lire per square metre.

The cost of a pavement made with granite, flint stones of the Adige, on a bed of sand and of sifted gravel, depth 0.15 metre, including the digging at 0.30 metre is 3.80 lire per square metre.

When a paved street, according to the last method, is also furnished with two bands of granite of only one line, each square metre costs as follows:

Breadth of street.	Cost.	Breadth of street.	Cost.
Metres.	*Lire.*	*Metres.*	*Lire.*
6	10.55	10	7.90
7	9.65	11	7.55
8	8.90	12	7.25
9	8.40		

If the line of granite is double, the prices per square metre are the following:

Breadth of street.	Cost.	Breadth of street.	Cost.
Metres.	*Lire.*	*Metres.*	*Lire.*
6	17.30	10	12.10
7	15.50	11	11.20
8	14.20	12	10.65
9	13.00		

At Bologna there are also a few streets paved with square stones, 0.15 metre in size, of granite, coming from San Fedelino (province of Biella); these square stones are placed on a bed of cement of the thickness of 0.15 metre; its cost per square metre is 30 lire.

The annual expense for maintaining the city streets paved by the aforesaid methods is about 0.12 lira per square metre.

CARLO GARDINI,
Consular Agent.

UNITED STATES CONSULAR AGENCY,
Bologna, January 17, 1801.

PROVINCE OF CATANIA.

REPORT BY CONSUL HEATH.

CITY STREETS.

The principal streets in Catania are very good, and the process of making is well worth imitating by cities in the United States. The foundation is of broken lava, 2½ inches and less in diameter, firmly cemented together with burnt clay and lime to the depth of about 8 inches; this is properly crowned and the stones pounded securely into place, presenting an even surface for the pavement.

The pavement in the best streets are of No. 1 hard lava; it is quarried very rough in blocks about 16 by 20 inches and 8 inches thick, and worked upon the spot at time of making the street.

These blocks are laid in cement, the edges being fitted with great nicety.

Driving on such a street is very comfortable. The comparatively smooth surface and large size of pavements give none of those disagreeable jilting sensations such as are common on our own paved streets. The paved streets are much preferred for driving to the country roads by the driving population.

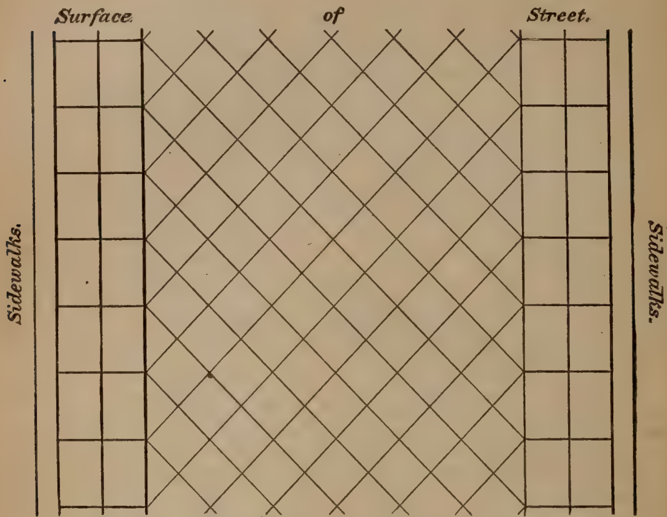
These streets present several ideas which seem to me to be an improvement on our own methods.

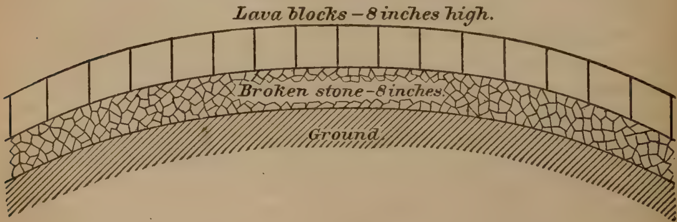
First, the large paving blocks used, giving a superior surface for driving or teaming.

Second, the comparatively smooth surface, with no open joints to hold dirt, making it an easy matter to sweep up all surface accumulations.

Third, the substantial foundation of cement and stone, absolutely preventing any dirt from working up from the ground.

I inclose a small plan of a street as described.





COUNTRY ROADS.

Country roads in the province of Catania are generally poor, and there is no regular process of making them. Only the principal ones can be driven over with a carriage.

Once a year the principal ones are repaired. This repairing is done in the winter or rainy season, and consists of crowning up the center of the road with a thin layer of broken lava, 2½ inches and less in diameter, of the poorest quality. On top lumps of clay are thrown, and frequent rains and constant traffic do the rest.

The poor quality lava gradually crumbles under wheels and hoofs, is finally mixed with the clay through the same agency, and, strange to say, after a few months makes a fairly good road.

This process, however, has no merits excepting economy, and I hope none of my countrymen will try road making on this plan.

CHARLES HEATH,
Consul.

UNITED STATES CONSULATE,
Catania, January 24, 1891.

PROVINCE OF GENOA.

REPORT BY CONSUL FLETCHER.

More than 1,000 years before Columbus discovered the New World this province of Genoa, in which the great navigator was born, and this city, in which he passed his childhood and youth and was contemptuously called the "mad boy," boasted of fine roads and streets. To keep them in good condition at the present day the following methods are employed:

CITY STREETS.

A bed of sand 5¾ inches deep; upon this bed cut or worked parallelopiped siliceous stones are laid; they are placed so as to slope gently from center of street to sidewalks. Each block of stone is about 11⅔ inches wide, 7⅔ inches thick, and 2 feet 3½ inches in length. The face of each is notched or grooved, so as to afford a sure foothold for horses.

Sidewalks are constructed from similar material as above noted, but the stones are only 3¾ inches thick, and rest upon a bed of sand 3¾ inches in depth. The curbstones are also from same material. Each stone is 2 feet 9½ inches long, 7⅔ inches in thickness, and 9⅔ inches wide. All rest on a diminutive wall composed of ordinary stone cemented with hydraulic lime. The above for comparatively level streets.

Streets of considerable declivity (Genoa has hundreds of them) on which vehicles run are constructed of smaller faced stones, the average measurement of each being about 5¾ inches wide, 7⅔ inches in thickness, and 2 feet 5 inches long. Between each line or row of stone is placed a course of hard brick, called here *da çarroggio*, set on edge. This is to give horses a sure foothold. Both stone and brick rest on a stratum of sand 5¾ inches in depth.

Experiments have been made recently with small round blocks of oaken wood placed on a sand bed 5¾ inches deep, but so recent have these experiments been made that the durability of this style of street pavement is not yet ascertained.

There are fully 1,000 streets in Genoa too narrow to admit of carts or carriages. These streets are constructed of round or oblong flint stones set on a bed of sand 3¾ inches deep. Some of those narrow thoroughfares are so exceedingly steep that a pathway about 3.3 feet wide made of brick runs through the center. This style of work is called here *pagliola.* The brick affords a sure footing for pedestrians in rainy weather.

Certain other streets, such as those around the drive known as the Circonvallazione a Monte (circle of the mountain), and those in the suburbs of the city, bròken flint stones 9¾ inches in depth are placed upon the road-bed; over this mass is drawn by steam-power a great roller weighing 10 tons. When the stones are crushed into a fairly smooth bed or surface, water and gravel are sprinkled and scattered thereon, after which the roller is again called into play, and soon thereafter the street is ready for public use. Such thoroughfares are called macadamized roads. The sidewalks on these streets are made in a similar manner to those already described, and vary in width from 6 feet 5 inches to 9 feet 8 inches.

STREET EXPENSES.

Expenses incurred in making streets, sidewalks, and roads, wholly completed. per square foot.

Streets, as per first condition	$1.05.9
Sidewalks, as per first condition	0.55.7
Curbstones, as per first condition	0.26.3
Streets:	
Flint stone, second condition	0.09.5
Brick (Pagliolo), second condition	0.31.9
Broken flint stone (macadam)	0.14.5

If the cost of making streets, sidewalks, etc., as above quoted, seem very low, it should be taken into consideration that all the materials used in their construction can be found close at hand and in great abundance.

COUNTRY ROADS.

Country roads or highways are kept in order on the macadam plan, except that in many places the roller is not used.

A book—paper covers—containing 164 pages, is mailed with this report. It is entitled: "City of Genoa—Office of the Public Works. Special conditions for contract for the ordinary preservation of the streets, conduits, and accessory works." This work is published by the municipal government of the city of Genoa.

JAMES FLETCHER,
Consul.

UNITED STATES CONSULATE,
Genoa, Italy, February 12, 1891.

LOMBARDY.

REPORT BY CONSUL PEPPER, OF MILAN.

Italian legislation as to roads is to be considered distinctively under four heads: National, provincial, communal, and viccinale or neighborhood roads. There are subordinate roads of a private character of which the legislature takes no interest in or supervision of. These are under the control of local landholders who have small properties, and who build these roads for their own accommodation. The mode of building and the expense of the roads in Lombardy is uniform, the essential difference being the reasons existing upon the special locality in which the roads are running, namely, in a mountainous region the expense would be greater than in a plain open country.

In general roads in villages or near cities are paved with gravel taken from the beds of rivers which traverse the country. In the cities and in the large towns the ground is also paved. Nearly always the sidewalks are paved with these pebbles for the use of pedestrians, both sides of streets contiguous to which carriages and teams pass are similarly paved. Roads for vehicles are usually from 50 to 75 centimetres in width. The pavements are likewise of the same material, arranged on each side of the streets. Frequently instead of one row of these stones, two or more often come in contact, thereby connecting these streets together. The double roads are usually of stone varying from 50 to 70 centimetres in width, and the sidewalks are of the same width and of the same material. The sidewalks of towns and cities are widened in accordance with the taste and wealth of the proprietors. In the construction of these roads heavy pebbles are placed upon the earth, which contributes solidity and permanency, also contributing to the dryness and to the freedom from the effects of rain. This bed of heavy pebbles furnishes a strong superficiality, which helps the character of the pavement. The expense of the pavement is calculated at 1½ francs per cubic surface. Those of the pavements denominated grades for trams cost 20 francs per cubic surface.

It is understood that roads in Lombardy are everywhere provided lengthways with a channel into which the water runs. This is said in regard to the leading roads. Those in the open country are constructed in the same way, the water running on both sides for the mountainous localities. There is no gravel; the lack is supplied by stones or fragments obtained from rocks. There is the only difference in these roads in width. The national roads are usually from 8 to 9 metres in width, the provincial roads 6, the communal 5. Nevertheless, in the mountainous regions a similar width is tolerated, as also in the commune, the construction of which is obligatory in accordance with the law of 1868. However, this law is not generally obeyed in Lombardy, because the street system has existed for many years, and has reached a splendid development. The triple distinction of roads between national, provincial, and communal has reference solely to the construction and

maintenance by the national government. The provincial roads are built and sustained by the provinces; the communal by the communes; the national by the government. In general, all these roads may serve for purposes of great traffic. This advantage arises from the uniformity with which they are built. The communal roads being the principal ones, it follows that the traffic is the greatest.

It is impossible to furnish the exact cost of roads built in the open country, as it is termed by the Italians, because of the variety of the land, as it is more or less mountainous. In Lombardy, especially, where the great abundance of canals exist and the consequent need of roads to cross them, the building of palisades and walls make it very difficult to get at the expense. About one-half the country is included in what we have seen and the other half in the mountainous zone. Difficulties increase and the expense becomes greater where rocks are to be blasted. In the completion of these roads it is calculated that the expense of roads in Lombardy vary from 2 to 5 francs, and in some instances much more, per metre. This does not include the expense of the ground. It follows, from the data which I have gathered, that the provincial roads built in the last 30 years in Lombardy cost 35,000 francs a kilometre; that the communal average 7,000. Regarding the support of these roads, I am assured that for the communal, 60 to 80 cubic surface gravel per year for each kilometre. The provincial and national being wider and the traffic greater, there is from 100 to 400 cubic surface each year per kilometre. In fine the expense of maintenance varies from the minimum of 250 to 300 francs, and frequently increases to 1,000 francs per kilometre. The condition of roads of all descriptions in Lombardy is far superior to that of any other part of Italy. In a word, the area of this district, Lombardy, is 23,600 kilometres cubic surface, counting 20,000 kilometres for ordinary roads, national, provincial, communal, that is 20,000 kilometres of roads. Lombardy has 1 kilometre of roads for every superficial kilometre. Three fourths of these roads, 15,000 kilometres, belong to the communal category, the balance, nearly 5,000, are provincial, while the national are only about 500 kilometres.

GEO. W. PEPPER,
Consul.

UNITED STATES CONSULATE,
Milan, Italy, January 24, 1891.

MESSINA.

REPORT BY CONSUL JONES.

CITY STREETS.

The municipality of Messina, upon the advice of the city surveyor, draws up a schedule of prices, with the maximum wages for day laborers, hire of teams, prices of lime, stone, etc. Sealed bids, based upon

a reduction of so much per cent. on the aforesaid schedule of prices, are handed in and the contract for paving the streets is given to the lowest bidder.

There are four kinds of pavements in use: (*a*) Pavement made of paving stones, different sizes; (*b*) pavement made of cobblestones; (*c*) pavement made of pebbles or chippings; (*d*) pavement made with longitudinal and transverse lines of paving stones, the intervening spaces being filled in with cobblestones.

The streets are divided into three classes: (1) Streets with a horizontal, flat surface; (2) streets with a convex surface; (3) streets with a concave surface.

Three sizes of paving stones are used: (1) Dressed paving stones must be not less than 20 centimetres thick or deep and the sides from 20 to 50 centimetres long; square blocks of stone (lava) are generally used. The length of a block must at all events never be more than twice the width of the block. (2) The thickness of the paving stones, when dressed, must not be less than 15 centimetres and the sides not less than 20 centimetres nor more than 40. (3) The thickness must not be less than 12 centimetres and the sides not less than 20 nor more than 35 centimetres.

Curbstones must not be less than 70 centimetres long.

The sides of the paving stones must be at right angles with each other. The four sides of the first size paving stones must be worked smooth for a depth of 10 centimetres so that the adjacent blocks may fit closely together. The sides of the second and third sizes of paving stones must be worked smooth for a depth of 7 and 6 centimetres, respectively.

The excavation made prior to laying the pavement must be deep enough to contain the paving stones and allow for the bed on which they rest. The bottom of the excavation must be well rammed down with a heavy maul, and, if the ground should be soft and dry, it should be well saturated with water and rammed down whilst wet. The four kinds of pavements in use are: (1) Dry paving (lastricato a secco). The bed is formed of a layer of sand at least 20 centimetres deep, into which —having been well watered—the closely fitting paving stones are placed side by side. The joints, free from sand, are filled up with mortar made of pulverized hydraulic lime. (2) Paving with mortar (lastricato in malta). The paving stones are placed on a bed of mortar, the joints being filled up as above. (3) Paving with mortar on a bed of concrete. A layer of concrete (made of cement and small pebbles) not less than 20 centimetres deep is spread over the bottom of the excavation, and on this concrete the mortar and paving stones are embedded as in No. 2. The joints between the stones must not exceed 2 millimetres and should always be filled in with mortar. (4) Paving with cobblestones. The cobblestones (of granite or quartz) are oblong and so chipped with the hammer as to fit closely one with the other. The

length of these cobblestones is never less than 15 centimetres. The ground being prepared as for paving stones, the cobblestones are set in a bed of sand at least 10 centimetres deep and then covered over with sand, and having been thoroughly saturated with mortar, are well rammed down. Sometimes cobblestones instead of being set in a bed of sand are set in a bed of mortar.

The Messina municipality's latest price list for wages, paving materials, etc., is as follows:

Workman (stonecutter)	per day	$0.60
Day laborer	do	.40
Boy	do	.24
Women	do	.20
Wheelbarrow (hire of)	do	.01
One horse, cart, and driver	do	1.20
Two-wheel ox-cart, one yoke oxen, and driver	do	1.60
Four-wheel ox-wagon, one yoke oxen, and driver	do	1.80
Pack donkey and driver	do	.30
Pack horse and driver	do	.60
Broken stones	per cubic metre	1.00
Pebbles	do	.70
Dressed paving stones	per square metre	2.00
Curbstone 75 centimetres long by 40 by 20	per linear metre	1.00
Rock lime	22 pounds	.05
Ground lime	per cubic metre	2.00
Hydraulic lime	per ton	4.40
Sand	per cubic metre	.60
Digging earth and throwing it an arm's length, when soil is light	do	.06
When clay	do	.11
Cutting through soft rock	do	.23
Cutting through hard rock	do	.50
Rolling (including watering) done by rollers drawn by oxen	per square metre	.02
Chipping pavement	do	.06

In Messini the streets are paved with lava from Mount Etna, which is hard, durable, and not slippery when dressed. The cost of paving the main thoroughfares—Corso Vittorio Emmanuele, Corso Cavour—over which the heaviest hauling is done, is 12 francs, or $2.40 per square metre; side streets, 8.50 francs, or $1.75 per square metre.

WALLACE S. JONES.

UNITED STATES CONSULATE,
Messina, January 26, 1891.

TUSCANY.

REPORT BY CONSUL DILLER, OF FLORENCE.

STREETS OF FLORENCE.

The streets of Florence are divided into three longitudinal zones, of which one, the central, is for wheels and the two lateral for sidewalks. The central part reserved to wheels is made in a convex form, with a

center corresponding to about one forty-fifth of the chord. The material used for paving consists of first quality hard stone, in rectangular pieces, and costs 12.50 lire per square metre, including the rubble work underneath, set in ordinary lime and fluting the surface of the stone.

The two zones for sidewalks are paved with hard gray stone, consisting of one or two pieces with raised heading, 0.12 metres high, fluted at the surface, with a decline of 0.04 metre to each square metre. Said stones fixed in their place cost 7.80 lire per square metre.

The breadth of the zones is established in proportion to the breadth of the street and generally three-fifths for wheels and two-fifths for sidewalks.

The maintenance of a street, made as above, costs 0.26 lire per year for each square metre.

COUNTRY ROADWAYS.

Country roads in Tuscany are divided into national, provincial, communal, and parish roads, each supported respectively by said organizations. Sometimes adjoining provinces or communes contribute to the making and maintenance of the same road. The Italian law, dated March 20, 1865, provides for the manner of constructing and care of the different classes of roads.

The breadth varies from 5 to 10 metres, according to the importance of the road and the localities placed in communication thereby. That portion reserved for vehicles is usually three-fifths of the width of the road, the remaining one-fifth on each side, when practicable, being reserved for pedestrians. For the protection of traffic as well as of foot passengers, stone pillars, round, square, or rectangular, from 2 to 3 feet in height are placed about 4 or 5 feet apart, and where the roadway is dangerous these pillars are connected by a heavy piece of timber passing through them near the top.

Roadways paved with hard stone or granite, broken small, including digging, cost about $2.30 per square metre, if made with the common stone of the locality in the same manner, about $1.30 per square meter, and the ordinary country roads not so much used, made with stone and sand with a surface of gravel, cost about 40 cents per square metre. It is proper to mention here that in many cases the roads follow the course of the streams, especially in the mountain districts, and such materials as river stone, gravel, and sand are plentiful, hence the cost is small for material.

The yearly maintenance of highways average about 4 or 5 cents per square metre. When side walls are necessary to protect the road in case of precipices or river banks, they are built of the stone found in the locality, well cemented with lime and river sand, as are also the gutters to carry off the water.

The prevailing system for the maintenance of parish roads is of an-

cient date, viz, the compulsory attendance of all males over 15 years of age to perform free labor for a few days whenever the condition of the road renders such service necessary. The same rule holds good whenever the parish authorities agree to open a new road.

ISAAC R. DILLER,
Consul.

UNITED STATES CONSULATE,
Florence, January 30, 1891.

SICILY.

REPORT BY CONSUL PUGH, OF PALERMO.

There are perhaps few countries where a description of their road construction would be attended with the same unsatisfactory and unprofitable results as in Sicily. It is true that both city streets and country roads are constructed in accordance with national regulations, but the manner of building and appliances used are of such primitive character as to make a detailed account not only uninteresting but of no practical benefit, as the cost of street and road construction in Sicily would convey but meager idea of the cost of like construction in the United States, both on account of the abundance of materials and cheapness of labor.

MATERIALS.

Sicily is so distinctively an island of rock as to make the construction of streets and roads of any other material than stone, even were it to be had, absolutely out of the question.

The rock of Sicily is of two principal species, one a limestone abounding in such high percentage of lime as that the numerous crevices and caves in the mountains, made perhaps by volcanic action, are filled with nearly pure powdered lime, which taken from such receptacles constitutes a large, important, and inexpensive factor in road construction when mixed with the rock itself, which is easily broken; the other, a soft porous rock of coral and shell formation, so soft in fact as to be susceptible of being cut from the quarries with ordinary axes. This latter, while resembling the softest and most porous sandstone, also possesses lime in such considerable quantities that the cuttings and easily crushed smaller pieces form another important element in the construction of the less important city streets, that, like country roads, are built of broken limestone with the cuttings from this soft stone spread over to obtain a smooth surface.

CITY STREETS.

On account of the abundance of limestone, as well as cheapness of labor in preparing it, the principal streets of cities are paved with solid blocks of this stone, from 18 inches to 2 feet square by 8 to 10

inches in thickness, placed on a concrete bed of broken stone, lime, and sand, the blocks being laid in mortar for the purpose of properly imbedding the stone and leveling the surface. The durability of streets thus constructed is so apparent that comment is unnecessary.

The cost of paving a street with the black stone as above mentioned is 15 lire or $3 per square metre. (A metre is 3 feet 4 inches.) The wages paid for labor is as follows: To the stonecutters, who shape and fit the blocks, per day of 11 hours, 60 cents; to ordinary laborers, same hours, 40 cents; to boys, who beside their other work, cut large portions of the stone, 30 cents.

COUNTRY ROADS.

Country roads are constructed wholly of broken stone, the crude lime above mentioned and sand, compressed with heavy cylindrical stone rollers, this admixture with the first rainfall forming a solid concrete mass.

The construction of roads in this manner is simplified and materially aided here by the fact that the substructure is solid rock, the thin stratum of soil varying only with the unevenness of the underlying rock.

With the exception of carting the larger stone, all the material used in the construction of both streets and roads is moved by hand. The broken stone and sand is carried in baskets, the soil carried from place to place in the same manner in leveling the grade, and a great portion of this is done by boys from 13 to 18 years of age.

The cost of the less important city streets and country roads paved with broken stone, spread superficially with lime, sand, and rolled as above described, is 76 cents per square metre; country roads, without the sand, 60 cents; while the wages paid per day of 11 hours is as follows: To the master workmen who have charge of grading, leveling, etc., 60 cents; to common laborers, 40 cents; to boys working at either, 24 cents; to horse and cart for transportation of unbroken rock and sand, together with the owner who must load and discharge same, $1.20.

PAYMENT FOR STREET AND ROAD CONSTRUCTION.

For the purpose of showing the sources from whence the expense of street and road construction is derived, a translation of those portions of the Italian laws bearing upon the subject are here given:

DESCRIPTION OF STREETS.

ARTICLE IX. Common streets of public use are classified into national, provincial, municipal and vicinal streets.

National streets.

ARTICLE X. National streets are:

(*a*) The long lines of roads which in their course join directly several of the principal cities of the kingdom or the latter with the nearer first-class commercial ports.

(*b*) Those joining the foregoing with the long commercial lines of neighboring states.

(*c*) Those having exclusively a military scope.

ARTICLE XI. There can not be a national road between two points of territory joined by a railroad. When railroads are opened up to public use, running in the same direction as existing national roads, the latter shall pass to the class of provincial roads at the beginning of the immediately subsequent solar year, should the opening happen within the first half of the year, and at the beginning of the following second year when it happens in the second half of the year. * * *

Provincial streets.

ARTICLE XIII. Provincial streets are:

(*a*) The streets which serve for the more direct communication between the chief place of a province and those of neighboring provinces.

(*b*) Those which lead from the chief town of a province to the chief places of the districts into which it is divided.

(*c*) Those joining the chief towns of a province or district with adjacent most important maritime ports.

(*d*) Those which are known to be of great importance to the industrial, commercial, and agricultural relations of the province.

Municipal and vicinal streets.

ARTICLE XVI. Municipal streets are:

(*a*) Those necessary to put in communication the greatest number of inhabitants of a community with the chief places of the respective districts and those of the neighboring towns. Communities separated each from the other by an elevated chain of mountain are not considered as being contiguous.

(*b*) Tho e which are in the interior of inhabited places.

(*c*) Those which lead from the most numerously inhabited places of a community to the respective parish churches and cemeteries. * * *

(*d*) Those serving to unite together the most important parts of a community. * * *

ARTICLE XIX. All other streets not described in the foregoing category or subject to public use are vicinal, * * * and are liable to the vigilance of the municipal authorities.

ARTICLE XXII. The land of the national streets is the property of the government; that of provincial streets belongs to the provinces, and that of municipal streets appertain to the municipalities. The following are considered as parts attached to the streets. * * * The lateral ditches which solely and principally serve for the drainage of the streets, the causeways, the elevated footpaths, and the art works of any kind established along the sides, sheltering houses and those of street guardians. * * *

In the interior of cities it is considered as constituting parts of the municipal streets the squares, spaces and narrow streets contiguous thereto, and on the public lands, the habits, existing conventions, and private rights remaining in full force.

The branches of national and provincial streets within the limits of a city or town constitute part of the municipal streets, save the aid by the government or province in the expenses of preservation and betterment as per article XLI and following.

ARTICLE XXX. National streets and all structures alongside of the same to give passage to natural water flows, are constructed, adapted, and maintained at the expense of the government. * * *

ARTICLE XXXVII. The construction, systemization, and maintenance of provincial streets and the works embellishing them are made at the expense of the province in

which they are located, or of two or more provinces joined in copartnership, voluntary or obligatory, in virtue of law when such streets extend into more than one province.

Article XXXIX. For the construction, systemization, and maintenance of municipal streets, the respective municipalities provide either separately or in copartnership with other municipalities, they concurring together in the expenses according to the degree of interest of each. * * *

Article XLI. The systemization and maintenance of branches of municipal and provincial streets comprised within populous towns or cities, are to be supported by the respective municipalities under the technical surveillance of government or provincial engineers. In respect to the maintenance thereof the government or the province gives the municipality an annual indemnity equal to the expense of maintenance of a contiguous branch of street of like length in the identical condition outside the populous places. * * *

Article XLII. When the government or provincial administration thinks the total renewal necessary of a branch of national or provincial street comprised within a populous place, it, as far as the normal width of the street, supports the relative expense. * * *

(*a*) Entirely in towns having less than 1,000 inhabitants.

(*b*) One-half in towns having less than 4,000 inhabitants.

(*c*) One-fourth in towns having 4,000 inhabitants and upward.

Article LI. The reparation and maintenance of vicinal streets are supported by those who make use of them in going to their properties either if the latter are or are not contiguous to the same streets, when by right or custom such a support may not be against determinate properties or persons. The municipalities could also be held to a concurrent share in the repairing expenses of the more important vicinal streets.

COST OF MUNICIPAL STREETS.

The average cost of each kilometre of municipal street is as follows:

In plain land	$400
In hilly land	800
In mountainous land	1,600

The depth of the pavement of country roads varies from simply smoothing the surface of rock over which the roadway passes to a pavement of broken stone 6 inches in depth, and the effect of such road making upon contiguous land can not be estimated, as there is neither a market for nor sale of farming lands in Sicily.

Horace C. Pugh,
Consul.

United States Consulate,
Palermo, Italy.

HOLLAND.

ROTTERDAM AND SCHIEDAM.

REPORT BY CONSUL GARDNER.

ROTTERDAM.

The materials employed for street paving in Rotterdam are bricks of clay, bricks of scoria or slag, and blocks of limestone and porphyry. The clay bricks are manufactured in the Netherlands, along the river

de Waal; the scoria bricks by the Tees Scoria Brick Company, of Middleborough-on-Tees (England); while the limestone and porphyry come from Belgium, and are cut in blocks at the quarries.

The uniform and only paving foundation in Rotterdam is a bed of sand, carefully packed; and the thickness or depth of pavement upon this bed is as follows: Clay bricks, 4½ inches; scoria bricks, 5 inches; limestone and porphyry, 6 inches. "The underlying soil there, as in other Netherlands cities," says the adjunct director of public works in Rotterdam, "presents great difficulties in the way of a level pavement surface, being for the most part formed of sand and turf unevenly compressed, and affording but indifferent subfoundation for heavy traffic." Nevertheless, the pavements in Rotterdam are, despite the difficulty here cited, remarkably well maintained.

The average cost to the city for its clay-brick pavement is 62½ cents (American) per square yard; for limestone, 62½ to $1.25 per square yard; for porphyry $1.56 and for scoria brick $1.25 per square yard—all put down. The original work of paving, and the work of maintaining pavements, is at the expense of the municipality, and is done by workmen in the city's employ. The original cost of streets is at the charge of private owners only when at their option streets are opened through their own property with the view to increase valuations. In such case, the streets being properly made, are accepted by the city, and thereafter maintained at the city expense.

As to the average duration of the different varieties of pavement employed, the city officers of Rotterdam are unable to give authoritative information, and are also unable to state with accuracy the total mileage of paved streets or the proportion of each pavement in use.

The present average cost to Rotterdam (population, 210,000) for maintaining and extending its paved thoroughfares is $40,000 per year. Ten years ago the average annual cost was $32,000.

Asked, "which pavement, in view of the experience of Rotterdam, does the public works department deem to be the best and most economical for light traffic and heavy traffic, respectively?" the adjunct director replied, "for light traffic, our Netherlands brick; for medium traffic, Scoria bricks and the best kinds of limestone; for heavy traffic, paving blocks of porphyry."

Rotterdam streets, it is to be added, are built for heavy teaming; there is almost no driving for pleasure. The din of traffic over the unyielding stones is ceaseless and distracting. Rotterdam pavements are possibly the best for the needs of this always busy, always toiling city. But, on the whole, even in the judgment of many of the good people of Rotterdam, their street-pavement system is, for other cities, a very good system to avoid.

SCHIEDAM.

This city (population 26,000) employs in its street making, river sand, clay brick, and granite. The brick are of Netherlands manufacture; the granite comes (cut in blocks) from Belgian quarries. No artificial stone is used.

Upon its sand foundation the brick pavement of Schiedam is 4½ inches depth; the granite, 5$\frac{9}{10}$ inches. The former costs, put down, on the average, 58 cents (American), and the latter $1.50 per square yard. Only small side streets and the sidewalks of principal streets are brick-paved, granite being used for the roadways of all main streets.

All original work and all work of maintaining the streets is done under the authority and at the expense of the city, by city employés. The present average annual cost of street maintenance in Schiedam is $5,200.

WALTER E. GARDNER,
Consul.

UNITED STATES CONSULATE,
Rotterdam, Netherlands, January 27, 1891.

NETHERLANDS PUBLIC ROADWAYS.

[Translation of notes relating to Netherlands public roadways, furnished by the honorable secretary-general of the Netherlands department of public works.]

[Inclosure in Consul Gardner's Report.]

The general system of dikes in the Netherlands is not created and maintained at the expense of the national treasury. There are, however, some dikes thus maintained, in pursuance of early conditions, or agreements entered into with a view to the general interest, or because of the utter inability of persons or communities to protect themselves. The general rule of the Netherlands is that dikes are at the expense of those whose property is protected by the dikes.

The public roadways over the dikes are usually at the expense of the several provinces, communities, or "polders" (drained lakes) benefited. Only in certain cases are some parts of these roadways at the expense of the General Government, for the same reason as is given above for the Government maintenance of certain portions of the dikes. By royal decree, however, a network of roads is assigned to be maintained by the Government, being so arranged that unhindered communication between the different parts of the country and with adjacent countries is secured.

The materials of which these roadways in the Netherlands are constructed are: (1) natural stone; (2) bricks; (3) gravel, or broken bricks; the material employed differing according as the ordinary traffic is heavy or light. The natural stone is used and recommended for the heaviest traffic, the bricks and gravel for lighter weights.

Including a sand bed of 0.20 to 0.30 metre deep, in which the bricks or natural stones are put down, the cost per square metre for road making is as follows: Natural stone, 3 to 6 florins ($1.20 to $2.40); bricks, 1.50 to 1.75 florins (60 to 70 cents); gravel, 1 to 1.50 florins (40 to 60 cents).

The price greatly depends upon the cost of transportation of the material used; the natural stone, for example, all being brought from foreign countries, at heavy outlay for freight. The prices above quoted do not include the expense of making the sub or earthen roadway. The average depth of the road pavements, including

the roadbed, is: For natural stone roads, 0.40 to 0.50 metre; for brick roads, 0.30 to 0.40 metre; for gravel roads (without sand bed), 0.20 to 0.25 metre. In many parts of the Netherlands a sand ground is found, and in such localities no special sand bed is required; but in all other cases (gravel roads excepted) the sand bed is uniformly made.

It is provided in the constitutional law that the King [the Queen regent] shall have supervision of all matters relating to "waterstaat," thus also including the dike roadways; while the law also provides that the provincial states respectively are to be charged with the adequate supervision of all public roadways within their own limits.

The artificial roadways over the Netherlands dikes are for the most part gravel roads, the cost of construction of which has been already stated. The total length of roadways in this country maintained by the Government is 1,983.696 kilometres. This figure does not include roads running alongside of canals or over Government dikes. As to the expense for yearly maintenance see Exhibit A hereto attached, stating the cost for the last 8 years. The cost of maintenance of each kind of roadway can not be given, as such cost is not separately specified in the contracts, which are usually made for 3 years.

The influence of the steady improvement of roadways in the Netherlands upon the value of real property is not easily stated in figures, as there are many other modifying conditions. In general and naturally it can be said such influence is very important.

Finally it is to be mentioned that several principal roadways have been and still are made and maintained by the various provinces with subsidies from the Government of the Netherlands, and by various towns with subsidies granted by the provinces.

EXHIBIT A.

Cost of maintenance and improvements of the great Government roadways in the Netherlands.

[One florin, 40.2 cents, American.]

Province.	Ordinary maintenance.							
	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Florins.	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*
Noord Brabantz	60, 211	58, 883	59, 023	59, 013	63, 520	59, 152	57, 636	64, 285
Gelderland	155, 907	156, 780	151, 795	146, 600	147, 814	147, 877	124, 130	125, 092
Zuid Holland	85, 872	103, 859	108, 000	95, 764	89, 750	90, 154	86, 955	83, 340
Noord Holland	62, 547	60, 286	59, 456	53, 760	54, 351	53, 923	84, 434	48, 971
Zieland	25, 767	23, 329	23, 554	23, 568	20, 905	21, 897	30, 859	20, 654
Utrecht	61, 071	79, 342	68, 101	64, 848	63, 800	54, 928	54, 554	53, 951
Friesland	54, 230	54, 041	51, 969	52, 250	46, 002	42, 706	45, 160	41, 359
Overyssel	88, 246	87, 962	87, 552	94, 009	94, 009	94, 009	98, 696	88, 258
Groningen	36, 577	29, 776	33, 977	47, 247	31, 776	29, 196	16, 071	15, 587
Dreuthe	18, 981	19, 939	18, 997	20, 570	20, 570	21, 900	21, 939	18, 867
Limburg	43, 585	43, 585	43, 585	43, 585	44, 386	44, 386	44, 386	43, 272

Province.	Improvements.							
	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Florins.	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*
Noord Brabantz	45, 057	35, 050	32, 828	21, 725	16, 814	19, 935	18, 117	1, 456
Gelderland	24, 911	21, 027	21, 748	11, 891	3, 821	814	11, 617	4, 601
Zuid Holland	20, 908	16, 993	13, 547	....	....	8, 860	....	....
Noord Holland	870	....	....	....	....	....	....	4, 422
Zietland	....	650	416	553	624	161	....	....
Utrecht	....	....	....	....	....	....	....	....
Friesland	13, 112	548	5, 126	4, 581	5, 770	731	....	1, 022
Overyssel	15, 647	30, 667	29, 874	18, 624	20, 246	23, 085	16, 033	27, 167
Groningen	31, 778	29, 799	17, 776	13, 619	13, 252	6, 550	1, 290	82
Drenthe	302	1, 995	3, 763	....	....	....	....	....
Limburg	4, 187	9, 376	8, 635	10, 949	10, 398	14, 454	12, 047	7, 538

RUSSIA.

REPORT BY CONSUL-GENERAL CRAWFORD, OF ST. PETERSBURG.

The streets and roadways of Russia are in a very primitive condition, and every year some new method is introduced from abroad looking toward the betterment of streets and highways.

It is difficult to say anything definite about the price of repairing the streets in the city, because this is done at the expense of proprietors, under private contracts, which show a great variation in prices and in methods.

The roads in Russia can be divided into three distinct categories, as follows: First, the highways; second, the roads in the suburbs of the city; third, the streets in the city itself.

HIGHWAYS.

The highways are the work of the ministry of ways and communications, and are made and maintained at the expense of the Government, no special tax being levied for this purpose. Toll-bars exist only on the eastern Siberian highway, or Sibirsky Tract, by which most of the tea is imported from China into Russia, coming through the Irkoutsk custom-house. There the peasants, who make a regular business of carrying these goods to and from Russia, pay a certain tax per horse or wagon, and although this toll is very small it is more than sufficient to maintain the road in good order and the surplus goes towards making new roads in Siberia.

Each province in Russia has its own management or zemstro, which receives taxes, expends such sums of money as have been allowed, and renders full statement of the general affairs to the different ministries.

In this manner, when there is a surplus in any province it is not turned over to the Government, but is used for the public improvement of the province. Thus these provinces levy no tax for the roads, and it follows that the Government grants them certain monetary benefits.

In some parts of the Empire, in the Crimea for instance, the roads are naturally very good, but this can not be said of all the provinces, for in the provinces of Tamboff, Saratoff, Kharkow, Riaxan, Novgarod, the roads are very bad, and apart from putting wooden bridges where absolutely necessary, and posts in the ground every 10 or 15 yards to indicate that it is the highway, nothing is done for their maintenance. Horses run in 1 foot of dust in dry weather, and are up to their knees in mud during wet weather, while all communication ceases in autumn and spring, and this is the reason why all traffic or business in Russia is done in winter with sleighs.

During summer all the principal cities which have railroad communication make their supplies, and can only get rid of them in winter, and even then nature must provide them with plenty of snow and frost,

otherwise the country is in distress. Such are the circumstances which attend highways. It can therefore be said that only such highways exist in Russia which have been built by the ministry of ways and communications and which are under its supervision, and I do not know of any besides the Siberian tract and the highway, built a few years ago, from the Yalta to Symferopol, along the littoral of the Black Sea, in the province of Tauride, known as the Crimea.

SUBURBAN ROADS.

The roads in the environs of a city are maintained entirely at the expense of the town. Their maintenance is given out under contracts, a definite sum being allowed per verst, and no tax is levied for this purpose. The roads are made of crushed cobblestones, which are placed about 1 foot deep along the road and beaten into a solid mass with sand-earth by the use of a heavy roller moved by horse power. Some other roads in the suburbs are made in the same manner as those in the city, namely, of cobblestones, hammered into the ground, as near to each other as possible, the spaces left open by the shape of the stone is filled up with sand and little bits of stone, which are brushed over, and the whole is beaten down by the aid of hand-rammers. This pavement costs about $2 per square fathom.

CITY STREETS.

The third category comprises the streets and roads within the city boundary. These are maintained in good condition by the house proprietors. There are four methods employed, the most common being the use of cobblestones as above described. Then comes the wooden pavement, which is made as follows: The ground or basis is well beaten in and when level two side planks are firmly fixed in the space which is to be paved and are maintained upright by the interception of boards which are put down on the ground as a floor. This floor is well tarred, and then the wooden cubes are placed in, pinned together with nails or wooden pegs.

This system costs $3.50 per square fathom. This includes both material and hand labor.

This system has been tested in a new form as a trial. The wooden blocks were in the shape of bricks, and had been left to moisten in a certain chemical preparation, which prevents the wood from rotting; the bricks, instead of being pinned one to the other, are affixed with cement. This means was introduced for the first time last year by some French engineers, and it is said that such a street will last 3 years; although somewhat more expensive than the ordinary pavement, still, if it should prove to endure the rigorous winter frost it will be largely adopted in Russia, where the roads have to be repaired each summer.

I might say here that when Alexander Dumas, the French author, returned from Russia, which he had been visiting, he was asked how

he had found the streets and roads, to which he answered that he had scarcely seen any, inasmuch as during the winter season they were covered with snow, and during the summer they were in process of repair.

Although the above may seem an anecdote, yet it represents a truth; for as soon as spring sets in all the principal streets are put under repairs, while the less important are repaired later in the season.

Asphalt is very little used for street pavement. Only two streets of little thoroughfare are paved with asphalt, and it has proved a failure for the contractors.

Two long streets of this capital were paved two years ago with blocks of hard stone, such as the streets of Paris and London, and although this process turned out very expensive, it is hoped to be cheaper in the end, especially so if it does not require to be repaired this year.

In some of the principal streets the wooden pavement is made obligatory, and any proprietor who refuses to concede to the ruling is promptly fined, and the work done by the municipal authorities at his expense.

J. M. CRAWFORD,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
St. Petersburg, March 21, 1891.

SPAIN.

REPORT BY CONSUL TURNER, OF CADIZ.

ROMAN ROADS IN SPAIN.

Since mankind constructed society and became distributed over countries roads have been necessary. From the time of Moses there have been royal roads. First the Egyptians, afterwards the Israelites, and then the Greeks called their lines of travel that were not used for special purposes royal roads, or the king's highways. In Greece the royal roads were inspected and cared for by the Senate at Athens. In Lacedemonia, Thebes, and other states they were under the supervision of the most eminent men. Their roads, however, were not the best of the ancients. It was reserved for a commercial city, Carthage, to build the first paved roads.

The Romans followed the example of the Carthaginians, and their great highways, which connected Rome with its provinces were the most renowned and durable ever constructed. All over Europe, Asia, and Africa, wherever their emperors ruled, they built roads that have been supposed, by the vulgar of different ages, to have been of supernatural origin. This is attested by the names applied to them in Italy, England, France, and Spain. In the last mentioned they have been known by such appellations as Calzada del diablo (road of the devil), Calzada de las gigantes (road of the giants), etc.

According to St. Isidoro, the first paved roads of Spain were built by

the Carthaginians, and the same authority states that the Phœnicians opened (and left to their successors) a road across the Pyrenees and the Alps many centuries before the Christain era.

The most ancient Roman road outside of Italy was in Spain, and led from Cartagena to the Pyrenees, where it connected with others that led across the Alps to Rome. This road was traveled by the legions of Scipio the Less. The reign of Augustus is renowned for the roads then completed. This emperor made the system of communication so complete that little else was left for his successors to do than to care for the roads already constructed. Of his successors Trajanus was the most zealous, as is shown by various inscriptions found in Spain, in preserving the public highways and in constructing others. His example was followed by Adrian, Lucius, and others, but afterwards the authority of the emperors decayed and little care was given to distant public works. The removal of the court to Byzantine by Constantine completed the abandonment of road building, and was the beginning of the ruin of that magnificent system of highways that laced Rome to its most distant provinces. The Romans divided their roads into military highways, called also consular or pretorian thoroughfares, and local *vias.* The first were built to facilitate the marching of armies and to connect the capital with the principal cities and strategic points. They were constructed and kept in repair by the imperial government. The second were the routes of commerce and connected towns and trade centers, and were constructed to facilitate the relations and intercourse of traffic. They were built and maintained by municipal governments.

These highways were pavements firmly and simply leveled, and of such solidity that remnants of those of the first class are still found in a state of fair preservation in various countries. They were generally narrow, being from 4 to 6 meters in width, and constructed as follows:

The road-bed was excavated, and in it was first placed a layer of stones. The stones of this bottom layer were sometimes united with mortar. Over it was placed a strata of plaster made of stone or brick pounded with mortar. This was followed by another of sand and lime or sand and earthenware clay, which, like its predecessors, was pounded and leveled with great force. The top was made of irregular stones united with cement. The road formed a pronounced curve between strongly made curbs, which at regular distances were elevated to serve as stiles for the mounting and dismounting of horses. All roads were supplied with mile-posts, the Roman mile being approximately equal to 1½ kilometers.

At a distance of about 30 miles apart on the principal routes the Romans established a series of stations called *mansiones.* Each of these *mansiones* was supplied with 40 horses and carts, oxen and pack-mules necessary for the transportation of baggage and other effects. Mid way between the *mansiones* were smaller stations called *mutationes*, where only 20 horses, etc., were kept. An ancient document, said to be the Itinerary of Antoninus Augustus Caracalla, shows the total

number of imperial or military highways to be 372, of which only 34 belonged to the province of Hispania, which is to-day known as Spain and Portugal. The total mileage of these 34 roads was 6,926. According to Coello, who collected data relating to the Roman roads of Spain, there were 20,000 miles constructed. He, of course, includes commercial routes, of which the itinerary referred to makes no mention. These roads were undoubtedly numerous. They are often referred to in the writings of Pliny and other historians.

Although the Itinerary of Antoninus Augustus Caracalla can not be accepted as a complete plan of the military roads of Rome, it is certain that it includes the most important, and is very useful in the study of Roman highways. For that reason I herewith present that part of it which refers to the Roman roads of Spain.

It shows the Roman names of the *mansiones* and the modern names by which their ancient sites are known to-day. The mileage is also shown.

Roman roads of Spain according to the itinerary of Antonino Augusto Caracalla.

1. ROAD FROM ITALY TO SPAIN AND PORTUGAL.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Summo Pyreneo	Coll de Pertus	......
Deciana	Junguera	16
Juncaria	Figueras	12
Cinniana	......	......
Gerunda	Gerona	27
Aquis voconis	Caldes de Malavella	......
Sece ras	Hostalrich	......
Praetorio	Llinás	......
Semproniana	La Roca	......
Arragone	......	......
Barcinone	Barcelona	22
Fines	Cerca del Castillo de Gélida	......
Antistiana	Junto á Moryos	......
Stabulo novo	Castellnou	......
Palfuriana	Alo del arco de Barà	......
Tarragone	Tarragona	24
Ad septimum decimum	Vilavert	......
Ad novas	Vinaixa	......
Ilerda	Lerida	......
Mendiculcia	Cerca de Algayon	......
Tolous	Monzon	32
Caum	......	......
Pertusa	Pertusa	18
Osca	Huesca	19
Bortinæ	Llano de Violada	......
Gallicum	Cerca de Zuera	......
Cæsar Augusta	Zaragoza	......
Allobone	Alagon	......
Balsione	Cerca de Mallen	......
Cascanto	Cascante	......
Gracurris	Cerca de Corella	......
Calagurra	Calahorra	29
Barbariana	Junto à Agoncillo	......
Vercla	Varea, cerca de Logrono	28
Tritio	Rodilla	18
Antiliana	La Tunta	......
Libia	Cerca de Leiba	18
Segasamunclo	Cerezo de Rio Tiron	7
Verovesca	Bribiesca	11
Tritium	Rodilla	......
Deobrigula	Rabé de las Calzadas	......
Segisamone	Sasamon	......
Dessobriga	Cerca de Osorno	......
Lacobriga	Cerca de Carrion de los Condes	30
Viminacio	Despoblado de Pozanova	......
Camala	Inmediaciones de Sahagun	24
Palantia	Hacia Rehegos	3
Lance	Cerro de Lancia	29
Ad Legionem vii Geminam	Leon	9

Roman roads of Spain according to the itinerary of Antonino Augusto Caracalla—Cont'd.

2. ROAD FROM ITALY TO SPAIN AND PORTUGAL VIA NARBONA.*

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Tarracona	Tarragona	......
Oleastrum	Cerca de Hospitalet	21
Subsalter	Coll de Balaguer	......
Tria capita	Percelló	23
Dertosa	Tortosa	17
Intibili	Cerca de la Jana	27
Ildum	Cabanes	24
Ad noulas	Onda	......
Sebelaci	Bechi	24
Sagunteum	Sagunto	22
Valentia	Valencia	16
Sucronem	Alcira	20
Sactabi	Jatiba	......
Ad statuas	Parluta del Toy	22
Ad turres	Mojente	9
Adello	Villena	24
Aspi	Aspe	24
Ilici	Elche	24
Thiar	Zeneta	27
Carthagine Spartaria	Cartagena	25
Eliocroca	Lorca	48
Ad morum	Navas de San Juan	24
Basti	Baza	26
Acci	Guadix	25
Acatucci	Cerca de Iznalloz	28
Viniolis	Cortijada de los Albunicles	24
Mentesa Castia	La Guardia	20
Castulone	Cazlona	25

3. ROAD FROM CORDOBA TO CASTULO.

Corduba	Cordoba	......
Calpurniana	Canete de las Torres	25
Urgaone	Arjona	20
Iliturgis	Cuenas de Lituergo	24
Castulone	Cazlona	20

4. ANOTHER ROAD FROM CORDOBA TO CASTULO.

Corduba	Cordoba	......
Ad decumo		......
Adlucos	Cerca de Montoro	3
Epora	Montoro	28
Uciense	Marmolejo	18
Castulone	Cazlona	32

5. ROAD FROM CASTULO TO MALAGA.

Castulone	Cozlona	......
Tugia	Despoblado de Toya	35
Traxinum	Near to Hinojares	16
Acci	Guadix	32
Alba	Despoblado de Albizu	32
Hactara	Huébares	24
Virgo	Campo de Dalias	34
Turaniana	Turon	16
Murgi	Near to Polapos	12
Saxetanum	Puerto de Almunecar	38
Caviclum	Cerca de la Torre de Calaturcos	16
Menova	Bizmiliana	34
Malaca	Malaga	12

*The same road as No. 1 as far as Tarragona.

Roman roads of Spain according to the itinerary of Antonio Augusto Caracalla—Cont'd.

6. ROAD FROM MALAGA TO CADIZ.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Malaca	Malaga	21
Suel	Valdesuel	......
Cilmana	Torre de las Bóvedas	24
Barbariana	Venta de guadiaro	34
Calpe cartiam	Torre de Cartagena	10
Portu Albo	Algeciras	6
Mellaria	Near to Tarifa	12
Bellone claudia	Despoblado de Bolonia	6
Besippone	Cerca de Barbate	12
Mergablo	Conil	16
Adherculem	Castillo de Sancti Petri	12
Gades	Cadiz	12

7. ROAD FROM CADIZ TO CORDOBA.

Gades	Cadiz	......
Adpontem	Puento de Zuazo	12
Adportum	Puerto de Santa Maria	14
Asta	Despoblado de Mesa de Asta	16
Ugia	Cabezas de San Juan	27
Orippo	Torre de los Herberos	24
Hispali	Sevilla	9
Basilippo	Cerro del Cincho	21
Carula	Puebla de Cazalla	24
Ilipa	Cerro de Repla	18
Ostippo	Despoblado de Teba la Vieja	14
Barba	Cerca de la Pizarra	20
Anticaria	Antequera	......
Angellas	Castil Azul	24
Ipagro	Debesa de los Moriles	20
Ulia	Montermayor	10
Corduba	Cordoba	18

8. ROAD FROM SEVILLA TO CORDOBA.

Hispali	Sevilla	......
Carmone	Carmona	......
Obocula	La Moncloa	42
Astigi	Ecija	16
Addras	Venta de Siste Torres	12
Corduba	Cordoba	24

9. ROAD FROM SEVILLA TO SANTA PONCE.

Hispali	Sevilla	......
Italica	Santa Ponce	6

10. ROAD FROM SEVILLA TO MÉRIDA.*

Celti	Aldea de las Navas	27
Regiana	Regna	44
Periana	Villa Franca de los Barros	44
Emerita	Merida	27

11. ROAD FROM CORDOBA TO EMERITA.

Corduba	Cordoba	27
Mellaria	Cerro del Castello	52
Artigi	Despoblado de Argallen	36
Mettellinum	Medellin	32
Emerita	Merida	24

*It is the same road as No. 8 as far as Astigi.

Roman roads of Spain according to the itinerary of Antonino Augusto Caracalla—Cont'd.

12. ROAD FROM OBISPO TO EMERITA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Olisipone	Lisboa	.....
Equabona	Coina	12
Catobriga	Setúbal	12
Caeciliana	Cerca de Agualoa	8
Malateca	Near to Marateca	16
Salacia	Alcacer-do-Sal	12
Ebora	Ebora	44
Ad-Adrum Flumen	Alandroal	29
Dipone	Near to Elvas	12
Evandriana	Near to Badajoz	17
Emerita	Merida	9

13. ROAD FROM SALACIA TO OSSONOBA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Salcia	Alcacer-do-Sal	.....
Aranni	Between Aljustrel and Castroverde	.....
Ossonoba	Faro	16

14. ROAD FROM OLISIPO TO EMERITA.*

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Olisipone	Lisboa	.....
Aritio Praetorio	Cerca de Salvatierra	38
Abeltiero	To the east of Almeyrim	28
Malusaro	Ponte de Sor	23
Ad Septem Aras	Near Albuquerque	8
Budua	Nuestra Señora de Botoa	12
Plapiaria	Dispoblado de la Matañza	8
Emerita	Merida	30

15. ANOTHER ROAD FROM OLISIPO TO EMERITA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Olisipone	Lisboa	.....
Jerabriga	Villafranca de Jira	30
Scalabin	Santarem	32
Tubucci	A league from Abrantes	32
Fraxinum	Between Gafete and Castelho da Vide	32
Mundobriga	Ruinas de San Anton	30
Ad Septem Aras	Near Albuquerque	14
Plageraria	Despoblado de la Matañza	20
Emerita	Merida	30

16. ROAD FROM OLISIPO TO BRACARA AUGUSTA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Olisipone	Lisboa	.....
Jerabriga	Villafranca de Jira	39
Scalabin	Santareém	33
Sellium	To the east of Thomar	32
Conembriga	Condeixa Velha	34
Acminio	Counbra	10
Talabriga	....	40
Langobriga	Towards Cortegaza	28
Catem	Villanueva de Caia	13
Bracara	Braga	35

17. ROAD FROM BRACARA TO ASTURICA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Bracara	Braga	.....
Salacia	Asella	20
Praesidio	Gralhas	36
Caladuno	....	16
Ad Aquas	Chaves	18
Pinetum	Pentes	20
Roboretum	Ruinas de Valdetelelhas	35
Compleutica	Castrelo	29
Veniatia	Vime	25
Petavonium	Despoblado de Sansueña	28
Argentiolum	Near Distriana	15
Asturica	Astorga	14

* Dierent from No. 12.

Roman roads of Spain according to the itinerary of Antonio Augusto Caracalla—Cont'd.

18. ANOTHER ROAD FROM BRACARA TO ASTURICA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Bracara	Braga	......
Salamana	Travassos	21
Aquis Originis	Rio Caldo	18
Aquis Querquennis	Baños de Bande	14
Geminas	Castillo de Sandias	16
Salentibus	Tióira	13
Praesidio	Castro Caldeilas	18
Nemitobriga	Puento Navrea	13
Foro	Close to Rua	19
Genestario	Near Gestoso	18
Bergido	Ruinas del Biargo	13
Intesamnio Flavis	Onamiol	20
Asturica	Astorga	30

19. ANOTHER ROAD FROM BRACARA TO ASTURICA.

Bracara	Braga	......
Limia	Puente del Limia	19
Tude	Tuy	19
Burbida	Borbeu	16
Turogua	Ruinas close to Turon	16
Aquis celenis	Caamiña	24
Tria	Santa Maria de Tria	12
Asseconia	Quion	23
Brevis	Mellid	12
Martaie	Puente de Meryaboy	20
Luco Augusti	Lugo	13
Timalino	To the east of Baralla	22
Ponte Neviae	Nagales	12
Ultaris	Ruinas del Bierzo	16
Bergido		20
Tuteramuco	Onanial	20
Asturica	Astorga	30

20. ROAD BY THE COAST OF BRACARA TO ASTURICA.

Bracara	Braga	......
Aquis celenis	Caldas de Reses	*165
Vico Spacorum	Vigo	.....
Adduos pontes	Pontevedra	*150
Grandimiro	Dimo	*180
Trigundo	Puente Signsiro	24
Brigantium	Betanzas	30
Caranico	La Giana	23
Luco Augusti	Lugo	24

21. ROAD FROM ESCERI TO PAX TULIA.

Esuri	Castromarin	......
Balsa	Near Tavira	24
Ossanoba †	Faro	16
Serpa	Serpa	13
Fines	Near Pamogo	20
Arucci	Aroche	25
Pace iulia	Beja	16

* Stadia.
† From here continues the road No. 13 as far as Salacia, and according to the road No. 12 to Ebora.

Roman roads of Spain according to the itinerary of Antonino Augusto Caracalla—Cont'd.

22. ROAD FROM ESURI TO CASTROMARIN.

Ancient name of mansions.	Present names of ancient sites of mansions.	Miles.
Myrtili	Mertola	40
Pace iulia	Beja	36

23. ROAD FROM OSTIA FLUMINIS ANÆ AYAMONTE.

Præsidio	Villanueva de los Castillejos	24
Ad rubras	Cabezas rubias	28
Onoba	Huelva	28
Ilipla	Niebla	30
Tucci	Ruinas de Tejada	22
Italica	Santiponce	18
Monte Mariorum	Puerto Moral	46
Curiga	To the south of Monasterio	49
Contributa	Between Medina de las Torres and Calzadilla	24
Perceiana	Villafranca de los Barros	20
Emerita	Merida	24

24. ROAD FROM EMERITA TO CÆSAR AUGUSTA.

Emerita	Merida	......
Ad sorores	Baldio de Santiago	26
Castris cæcili	Caceres	20
Turmulos	Ventas de Alconetar	20
Rustic ana	Near Riobolos	22
Capara	Venta de Caparra	22
Caecilio Vico	Puerto Bejar	22
Ad lippos	Near Valdelascasas	12
Sentice	Frades	12
Salmantice	Salamanca	24
Sabariam	Torre del Sabre	21
Ocelo Durí	Zamora	21
Albocela	Toro	22
Amallobriga	Despoblado de Aronillas	22
Septimanea	Simancas	14
Nivaria	Despoblado de Cardiel	12
Cauca	Coca	22
Segovia	Segovia	29
Miacum	Despoblado de los Meagues	29
Titulciam	Bayona de Titulcia	24
Complutum	San Juan del Viso, near Alcala de Henares	30
Arriaca	Guadalajara	22
Cæsada	Despablado de Monte	24
Segontia	Sigüenza	23
Arcobriga	Arcos de Medinaceli	27
Aquæ Bilbitanorum	Alhama de Aragon	16
Bilbili	Calatayna	24
Nertobriga	Calatoras	21
Segontia	Near Peraman	14
Cæsar Augusta	Zaragoza	16

25. ANOTHER ROAD FROM EMERITA TO CÆSAR AUGUSTA.

Emerita	Merida	......
Lacipea	Villavieja	20
Leuciana	Valdecaballeros	24
Augustobriga		22
Toletum	Toledo	55
Titulciam*	Bayona de Titulcia	24

26. ROAD FROM ASTURICA TO CÆSAR AUGUSTA.

Asturica	Astorga	......
Bedunia	San Martin de Torres	20
Brigeco	Villabrazaro	20
Vico Aguario	Despoblado de Castro-Torafe	27
Ocelo durí	Zamora	14

* From here the road No. 24 continues to Cæsar Augusta.

Roman roads of Spain according to the itinerary of Antonio Augusto Caracalla—Cont'd

27. ANOTHER ROAD FROM ASTURICA TO CÆSAR AUGUSTA.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Asturica	Astorga	......
Brigeco	Villabrazaro	40
Intercantia	Villanueva del Campo	20
Tela	Near Gaton	22
Pallantia	Palencia	......
Pintian	Alto de las Pinzas	24
Raudam	Roa	40
Cluniam	Coruña del Conde	26
Uxamam	Osma	24
Voluce	Calatañazor	25
Numantia	Garray, near Soria	25
Augustobriga	Muro de Agreda	23
Turiasone	Tarazona	17
Caravi	Near Magallon	18
Cæsar Augusta	Zaragoza	37

28. ROAD FROM TURIASO TO CÆSAR AUGUSTA.

Turiasone	Tarazona	......
Balsione	Near Mallen	20

29. ROAD OF EMERITA TO CÆSAR AUGUSTA BY LUSITANIA.

Emerita	Merida	......
Metellinum	Medellin	......
Contosolia	Magacela	15
Mirobriga	Capilla	36
Sisapone	Almaden	13
Curcuvium	Caracuel	20
Oretum	Nuestra Señora de Oreto	......
Ad Turres	Nuestra Señora de las Virtudes	26
Mariana	Nuestra Señora de Mariena	24
Ramini	Cerro de la Mesa	30
Alces	Near Miguel Esteban	40
Vico Cuminario	Despablado de Dancos	24
Titulciam	Bayona de Titulcia	18

30. ROAD FROM LAMINIUM TO TOLETUM.

Laminio	Cerra de la Mesa	......
Murum	Despablado, two leagues from Villaharta	27
Consabro	Consuegra	23
Teletum	Toledo	44

31. ROAD FROM LAMINIUM TO CÆSAR AUGUSTA.

Laminio	Cerro de la Mesa	......
Caput fluminis anæ	Nacimiento del Guadiana	7
Labisosia	Lezuza	14
Parietinis	Parazos Viejos	22
Saltici	Chinchilla	16
Ad putea or Ad pullem	Nuestra Señorá de Belen	32
Valebonga	Valbona	40
Urbiaca	Concud	20
Albonica	Despoblado de Gallel	25
Agiria	Near Villafranca	6
Caræ	Villacadima	10
Sermone	Luco	14
Bilbilis	Calatayud	......

32. ROAD FROM ASTURICA TO TARRACO.

Asturica	Astorga	......
Vallata	Valladangos	16
Interamnio	Near Antimio	13
Palantia	Near Reliegos	14

Roman roads of Spain according to the itinerary of Antonino Augusto Caracalla—Cont'd.

33. ROAD FROM CÆSAR AUGUSTA TO BENEARNEEM.

Ancient name of mansions.	Present name of ancient sites of mansions.	Miles.
Cæsar Augusta	Zaragoza	......
Foro gallorum	Gurrea del Gallego	30
Ebellino	Lliná's del Marcuello	22
Tacca	Taca	24
Summo Pyreneo	Puerto de Canfran	......

34. ROAD FROM HISPANIA TO AGUITANIA.

Vindeleia	Santa Maria de Bivarredonda	12
Deobriga	Puentelarrá	14
Beleia	Near Estavillo	15
Suissatio	Zuazo	13
Tullonio	Towards Ascarza	7
Alba	Salvatierra	12
Araceli	Arbizeé	21
Alantone	......	16
Pompelone	Pamplona	8
Torisa	Towards Espinal	22
Summo Pyreneo	Puerto de Roncesvalles	8

ROAD MAKING IN SPAIN.

General plan.—Roads are of three classes. Those of the first being 8; those of the second 7, and those of the third 6 metres in width.

Roads of the first order are the most useful and important. They are generally the thoroughfares that connect Madrid with the capitals of the provinces, the departments of the navy, and the principal ports of the kingdom; the branches that lead to some of these points from a railroad or a highway of the first order, those which join two or more railroads passing by a city of not less than 15,000 inhabitants, and those which unite two or more highways of the first order, passing by some capital or center of population or traffic, either of the interior or coast, provided it exceeds 20,000 inhabitants.

Roads of the second order are those which place two provincial capitals in communication, those which connect a railroad with a highway of the first order, those which starting from a railroad or a highway of the first class terminates in a head town (a town that is not under the jurisdiction of another) or one that has a population of more than 10,000 and those which in the Balearic Islands put the capital in communication with other seaport towns or unite points of production and exportation.

Roads of the third order are those which do not come under any of the foregoing definitions. Roads of the third order are generally useful to one or two towns only.

Plans and specifications of a road determine its route, longitudinal and transversal outlines, cubical movement of earth, etc., gives a

description of the work and estimate of its cost, and states whether it is to be built of the ground and material adjacent to the road or of material to be brought from a distance.

Direction or route of a highway or the points it is to serve are always based upon political commercial or strategic considerations and reduces the problem to a search for the most available route between the determined points. If there be no impediment it is clearly understood that the most direct should be selected, but sometimes on account of the ownership of certain lands being vested in influential parties, ecclesiastical or civil corporations, and for many other reasons arising from the topography of the country between the given points it has been found convenient in Spain to make indirect and curved roads. It has also been customary to follow the bed of streams, such routes offering the lines of least resistance.

Grades, etc. The upward slope of a Spanish road must not exceed 5 centimetres to the metre. The water shed or transversal slopes must not rise to exceed 2 centimetres to the metre. At the sides of each road are paths that are used by the road overseers for places to deposit material for repairs. These paths are also used by footmen and as places for the erection of posts, etc. The outside margins of these paths terminate in gutters, into which the lateral slopes of the road are expected to precipitate dust and rain. Suburban roads are sometimes paved with granite blocks and asphalt, or with a concrete of broken stones, lime, sand, gravel, and clay, but it is seldom that a country road is constructed of any other material than that of the adjoining land.

HISTORY OF ROAD BUILDING.

Highways, such as are known to the present age, did not exist in Spain before the middle of the eighteenth century. Before this date Spanish roads were simply paths. Reforms were inaugurated, but in almost every case by private individuals, who, encountering more or less difficulty, built bridges across the principal rivers. The foregoing does not mean that there were no roads in Spain during the middle age, for there are documents which show that some attention was paid to road building, but it is impossible to unite such documents and ascertain clearly the extent of such undertakings, neither can they be compared with what has since been done.

In 1749 Fernando VI constructed the highway from Reinoso to Santander, and some pieces of the Guadarrama, employing soldiers for the work. To this and to the building of some roads in the Vascongada and Navarra provinces is limited all that was done in 12 years in this branch of public work.

In 1761 the government first commenced to fix its attention upon the subject and to dictate regulations for the classification, construction, and conservation of general highways, paying particular attention to the roads from Madrid to the royal resorts, and from Madrid to Barcelona.

The dispositions of 1761 and the modifications of 1778 were unsuccessful, and no real advancement was made.

In 1794 the supervision and building of public roads was delegated to a special bureau of the government. But this, too, proved unsatisfactory on account of a lack of road-building intelligence in the personnel of the bureau. The only good roads of that time were built under the direction of foreign engineers, or of the Spanish military engineers, whose knowledge of such undertakings was vastly superior to that of the bureau that the state intrusted with the work.

Up to this time, right ideas as to permanent estimates of expenditures for preserving and constructing roads, and as to material, etc., were not dominant. This will be readily understood when it is known that at the end of the past century there were in Spain only 2,000 kilometres of road, in a fearful state of conservation, and 605 bridges to show as the results of over 50 years of endeavor.

Nothing better can be said of the present century until the year 1834. But it is just to say that now progress of a substantial character is being made. The wars that have received the energies and treasure of the country explain the fact that up to the year above cited the sum total of highways had reached but 4,700 kilometres, and they were in a wretched state of preservation.

In 1833 a bureau of roads, highways and canals was created, and a special school established for the education of civil engineers. This school graduated its first corps of engineers in 1839. At the end of the first Carlist war, attention was again aroused upon the bettering and repairing of public highways, and some repairing was done, and a few new roads commenced from Madrid to the coasts and frontier. Development was, however, very slow, because even though the state had good plans and intentions, they could not be executed because of the bad state of the treasury. The bureau struggled against these difficulties, and at the opportune moment was able to dictate amendments to the existing law. Thus in 1842 a law was adopted which brought into existence a national corps of roadbuilders. They are called *peones camineros*, and are classified and uniformed, and are employed by the state in building and repairing roads. They constitute a distinct branch of the public service. This change was important, and soon placed experienced workmen under intelligent direction.

From 1834 to 1856 4,800 kilometres of road were completed, and 3,000 more projected.

At the present time, according to the latest data (1888), the length of the completed public roads of Spain is as follows:

	Kilometres.
First order	6,873
Second order	8,338
Third order	11,097
Total	26,308

The kilometre equals 0.621376 of a mile.

In addition to the above amount there are 31,000 kilometres projected. I mean by this that no work has been done on the 31,000 kilometres, but that part of the legal preliminary steps have been taken to establish additional roads aggregating that length.

GENERAL ROAD SYSTEM.

Roads of the first, second, and third order form what is called the general system.

Modifications of the general system.—To introduce a road into this system it is necessary to draft a memorial outlining the proposed route. This is submitted to the city councils along the proposed line, to the provincial assembly, to the council of agricultural industry and commerce, to the chief engineer of the province, and to the civil governor of the province, who forwards it to the ministro de fomento, who consults with the council of roads, canals, and ports and determines whether the proposition to include the road in the general system shall be submitted to the Cortes. This minister determines whether the road shall be assigned to the first, second, or third order.

The above is also the mode of procedure when it is desired to vacate some road or part of a road included in the general system.

Formation of plans.—It is the duty of the ministro de fomento to propose plans within the legislative credits provided for making roads, always confining such propositions to highways of the general system. The approbation of all plans for highways belongs to this officer, who, upon information derived from the chief engineer of the province and the council of roads, canals, and ports, drafts the royal order of approval. After the approval of a plan it can only be modified by going through anew the process of formation.

Construction and repairing.—No road can be constructed until it has been classified and its plan approved by the ministro de fomento.

Each year the amount to be spent upon public roads is fixed and a specified sum designated for each class. In this way a harmonious development of the system is intended. In arranging expenditures preference is given to roads that have been left in an unfinished state.

The building of roads is let by contract to private corporations or individuals, or performed under the direction of the engineer corps of the council of roads, canals, and ports. If let to contractors the interests of the Government are guarded by a commission selected by this council.

The Government can impose separate taxes and tolls on roads for repairs and construction.

PROVINCIAL ROADS.

The provinces also have their system of roads. The board of public works of each province forms and presents to the diputacion (provincial assembly) a plan which includes all the highways that are of in-

terest to the province and determines the order of construction and improvement. This plan is placed before the public from 30 to 60 days, with all its details, for examination. During this time it is examined and discussed by the city councils of the province and by interested citizens. At the end of the time specified the diputacion examines the observations of the board of public works, of those of the provincial council of agriculture, industry, and commerce, and to those of the chief engineer of the province, and decides what shall be included in the system of public roads that shall be requested of the department of fomento. When this is done the civil governor of the province forwards the plan of the diputacion, with a proper memorial, to the ministro de fomento, who, after consulting the council of roads, canals, and ports, decides definitely what shall be granted. If he is favorable to the plan admitted, it is immediately announced by royal decree.

The same procedure is followed in adding to a system of provincial roads or in vacating them in whole or in part. If the plans do not affect the public domain, the approval of the diputacion is sufficient, otherwise they must also be approved by the civil governor. In either case the chief engineer of the province is consulted, and if there should be a disagreement it is adjusted by the ministro de fomento.

Building and repairing.—Work on a road can not be commenced until the estimated cost is provided for in the provincial budget. Repairing of roads must be paid from special funds collected for such purpose. If a road is to be paid for from the general funds of the province the submitted plans must so state.

The same rules, as to contractors, prevail in the province as in the state, inspection, etc., being delegated to the chief engineer of the province and officers of the board of public works.

The ministro de fomento can also inspect the building of such roads, and if not satisfied must communicate at once with the diputacion of the province, which must take immediate steps to remedy the defects cited. If the diputacion refuses to act, then the civil engineer of the province, in conjunction with the civil governor, must see that the work conforms to the requirements of the departmento de fomento. When a road is completed it must be accepted by the chief engineer of the province before it is used by the public. This is indispensable, and if any dispute arises regarding the acceptance it is taken first before the civil governor, whose decision can be reviewed and set aside by the ministro de fomento.

The provincial diputacion may levy tolls and taxes on the roads of the province to create a fund for building and repairing. It is necessary, however, to first secure the consent of the ministro de fomento to such levies.

ROADS AFFECTING TWO PROVINCES.

In such cases each province prepares a plan and sends it to the ministro de fomento, and if he should not approve either plan he is authorized to decide what shall be done without more ado.

HIGHWAYS SUPPORTED BY MIXED FUNDS.

These are roads that for various reasons are built and supported jointly by the state and a province. The chief reason for these mixed funds is the necessity of the road for the welfare of the province and of its financial inability to build it without aid from the general government.

RURAL ROADS.

By royal decree of April 7, 1848, the law of May 28, 1819, and that of May 4, 1877, all roads of interest to particular towns, cities, or localities were called caminos vecinales. They are not included in the system of national or provincial highways. They are also known as caminos rurales, *i. e.*, rural roads.

The construction and conservation of these roads have at times been under the control of the general government, and at other times municipalities have supervised and built them. This responsibility has been from the beginning of the present century in harmony with the tendencies of different governments towards centralization or local self-government.

The law of July 22, 1859, scheduled these roads as highways of the third class and placed them under the control of the general government. The law of November 14, 1868, placed them again under the control of city governments, and the laws of December 29, 1876, May 4, 1877, and regulations of August 10, originated the present mixed system. By this system city councils must provide for the roads under their jurisdiction which are those that have been constructed to satisfy the needs of their locality and are not therefor a part of the national system.

In order to secure a new road of this class its plans must be drafted by the engineer of public works under the authorization of the city council. This draft is submitted to the inspection of the public and any citizen can file objections to it. In the course of time the council considers the plan together with any objections that may have been filed, after which it is sent to the civil governor of the province, accompanied by an appropriate memorial. The governor then submits the plans, etc., to the civil engineer and to the provincial assembly (diputacion), after which it is returned to him with their findings for his disposition. Should the plan not meet with his approval he must return it to the city council with his objections. If the council refuse to accept his conclusions the whole matter is by appeal brought before the ministro de fomento at Madrid for final solution. Two or more towns or cities may be interested in the construction and maintenance of a road and there may be questions as at what point the responsibility of one ends and another commences. One may desire the building of a new road and another be unwilling to share the expense, etc. In all such cases the line of procedure is the same. The city councils send plans and memorials to the civil governor who confers with the

civil engineer and with the diputacion of the province before rendering his decision, which can be received and set aside by the ministro de fomento. Cities of less than 2,000 inhabitants can not submit plans, neither can those that are without resources to execute them. Cities that are satisfied with the facilities offered them by the system of national and provincial roads can not be compelled to assist in constructing rural or local ones.

The execution of the work of building a road can be let by contract, which is sold to the lowest responsible bidder. The bids are sealed, etc. Or it can be performed under the direction of a civil engineer selected by the city council from among persons of known professional rank and aptitudes.

As soon as plans have been approved the council must take immediate steps to complete the work.

The city council can, by securing the consent of the ministro de hacienda, impose and collect tolls for the use of the roads under their control. Application is made for this privilege to the ministro de hacienda through the department of the ministro de fomento.

PRIVATE ROADS.

These include all roads for the use of mines and other industrial works and roads of private estates. Such roads can be opened by first obtaining the consent of the civil governor of the province. If it becomes necessary for an individual to open a private road through the estate of a neighbor, the consent of the civil governor, who condemns the property of the route selected and assesses all damages, must be obtained. All expenses of procedure, condemnation, and damage must be paid by the party who petitions for the road.

If, in the course of time, a private road becomes desirable to the public, it is condemned as a private road and purchased for public use.

CRITICISM.

The defects of the foregoing laws and regulations of Spanish road building are plain. The activity of diputacion of the province and of city councils in constructing roads is dampened by the most absurd centralization of power in the ministro de fomento. The general government puts its hand upon or intervenes in the construction of the most insignificant local road, and by a complex system for a simple branch of public work uselessly consumes the energies of local assemblies of cities and provinces in addition to killing by slow degrees the spirit of local enterprise, which, if left to itself, would carry out the projects it initiates.

COST OF ROADS.

The original cost of roads depends upon the topography of the country. The material used is generally the adjacent soil.

I have not been able to secure information as to the first cost of roads, but I hazard the opinion that road-building in Spain is expensive,

for, although labor is cheap, it is a primitive kind, and in the end is more expensive than so-called high-priced labor of modern methods and implements. For instance, grading and leveling are done with material that are carried to position in small baskets balanced on the heads of laborers, who walk leisurely back and forth between the road-bed and the situation of the material. Each basket holds about three shovelfuls. Such a workman earns from 40 to 60 cents per day, but it should be remembered that the road-builder who uses modern methods and earns from $2.50 to $3 per day can easily do in from 8 to 10 hours ten times as much as the first-mentioned can in his working day of 10 or 12 hours. In extensive works the patient and slow-going donkey is substituted for the man with the basket. Each donkey is equipped with large saddle-bags made of Spanish grass, a kind of hemp. The pockets of these bags, one of which hangs on each side, are loaded with material. Forty or fifty of these animals and their attendants constitute a gang, and pass to and from the place of loading to the roadbed, sometimes with and at others without drivers. A gang or herd of donkeys and the men who load and unload them can not accomplish more in a day than could be done by a team of good horses, a revolving scraper, and 2 men.

STREET-BUILDING.

All these methods of road-building are true of street-making also. Instead of steam rollers and crushers, men level the streets with huge mauls. The annual cost of preserving the roads of Spain is about 600 pesetas per kilometre. In the province of Cadiz there are 375 kilometres, the care of which for 1890 cost 307,500 pesetas, or 820 pesetas per kilometre. In addition, the engineers and other road officials received about 37,000 pesetas in salaries and office rent.

In some of the provinces the cost of caring for the roads is as high as 1,400 pesetas, and in others as low as 400 pesetas per kilometre.

Of street-making I can say nothing that would be of interest. The cities of this part of Spain are of Moorish pattern and the streets are narrow and crooked. The systems of paving, etc., are like the sewer systems, obsolete.

Streets are named by city councils and change with the governments, as each city council desires to do honor to celebrated men by naming the streets of the city for them. Thus there are in almost every city of Spain streets called Calle Castelar, Calle Isaac Peral, Calle Sagasta, etc.

The houses are numbered, the odd numbers on one side the even on the other. The system goes no further, and streets are never numbered.

R. W. TURNER,
Consul.

UNITED STATES CONSULATE,
Cadiz, Spain, February 4, 1891.

SPAIN.

REPORT BY CONSUL BOWEN, OF BARCELONA.

COUNTRY ROADS OR HIGHWAYS IN SPAIN.

In Spain country roads or highways are either national or provincial. Those that are national are paid for by the nation, and those that are provincial are constructed under the management of provincial committees who spend not any fixed sum, during any term of years, but such sums as from time to time their work requires. Each province has a provincial committee. The national roads are equally cared for throughout Spain, and are declared, officially, to be equally good. The provincial roads, on the contrary, vary; those in the wealthier and more public-spirited provinces are equal to the national roads, while those in the poorer and more lethargic provinces are hardly worthy of comparison with anything except, perhaps, with one another. The material used is principally small, compact, hard stone, sometimes granite, sometimes limestone, and sometimes sandstone, according to the locality; and the system of construction is always that that was conceived by Macadam. The cost of construction depends on the kind of stone used, and in the distance it is drawn, but it never rises higher than 32 cents nor lower than 21 cents the square metre for an average thickness of 20 centimetres. The annual expenditure for repairs amounts to $3\frac{3}{5}$ cents the square metre. It is the opinion of all the bicyclists with whom I have talked in Spain that the roads in northern Spain are fairly good, while the roads in southern Spain are execrable. The president of one of the three bicycle clubs in this city of Barcelona assured me that Spanish roads are not to be compared with those of France or England, but that he hopes, now that the Spanish Government has a bicycle branch in its post-office department, that the roads of Spain will be made equal to any in the world; and he believes that no opposition will be made by the tax-payers, nor by those that will have to pay assessments, as the past has proven conclusively that improved roads improve the value of adjacent land, and I have no doubt that he also believes that they improve the owners by bringing them into easier and, therefore, closer communication with one another and with the rest of the world.

HERBERT W. BOWEN,
Consul.

Barcelona, Spain, December 18, 1890.

BARCELONA.

REPORT BY CONSUL BOWEN.

CITY STREETS OF BARCELONA.

The corporation of the city of Barcelona is charged with the construction and preservation of the pavements of the streets, and consequently pays the costs of new as well as of the maintenance of old streets. As a rule the owners of contiguous realty are not required to bear directly any part of the cost, but in special cases, as for instance when a new road is made for the benefit of the proprietor of a large building, or of a block of houses, the first cost is borne by individuals, but only the first cost.

The city of Barcelona is divided into two parts, of which one is the old city and the other is the new city, or "ensanche." The greater number of the streets in the old city are paved with stone, while only a few are paved with wood, asphalt, cement, cylindrical pegs, and with flags. Of the stone pavements a part were laid over 15 years ago, and consist of sandstone procured from quarries near to the city, and collocated or laid on a foundation or bed of sand from 12 to 14 centimetres deep.

They are placed at a distance of a centimetre from one another, and the intervening space is not filled with mortar or any other preparation, but with coarse sand. The pavements of stone laid since 15 years ago consist of harder stone, more or less silicious, brought from quarries distant from Barcelona and laid on a well-moistened foundation of sand 12 centimetres deep. The stones of this pavement are from 9 to 10 centimetres wide, 18 to 20 centimetres long, and 16 to 18 centimetres high. The old stone pavements cost from 15 to 16 pesetas per surface metre, while those laid during the last 15 years cost from 22 to 23 pesetas; but the difference is to be accounted for principally by the difference in the charges of transportation from the neighboring and from the distant quarries.

In the construction of wooden pavements in the old city, a plaster foundation was first laid, 15 centimetres deep, upon which were then placed blocks of the red pine of northern Europe or of the Swedish fir, 8 centimetres wide, from 18 to 20 long, and 15 high. These blocks were then cemented together with a mixture of Portland cement, fine sand, and water. To prevent the putrefaction of the blocks they were subjected to a bath of creosote and sulphate of iron. The pavements recently laid were constructed by contract with the conditions precedent that 20 years' time be given in which to pay for them, and that the cost per surface metre be from 25 to 26 pesetas, including the cost of maintenance during the 20 years.

The asphalt pavements that have been laid in the old city cost from 10 to 14 pesetas the metre, but they have proven unsatisfactory, as they were not laid with due respect to the terms of the contract.

Flag pavements have also been laid at a cost of 16 pesetas, and

although they have proven satisfactory for the use of carriages, they have not acquired general popularity.

At present several new kinds of pavement are being laid and tested. One kind is an artificial cement pavement, which consists of a hydraulic plaster from 10 to 12 centimetres thick, on which is laid a cover of Portland cement from 4 to 5 centimetres deep, mixed with coarse sand, and then rigidly rolled and compressed. The durability of this pavement is said to be great, and it is well adapted for the use of carriages and bicycles. Another kind consists of pegs that are made from the branches or trunks of the oak tree, and that are 10 centimetres long, and from 3 to 6 centimetres in diameter. These pegs are laid vertically over a layer of stone broken in pieces from 4 to 5 centimetres in size, and rigidly rolled and compressed, and covered with a coating of coarse sand from 5 to 6 centimetres thick. The spaces between the pegs are filled with sand. The cost of this kind of pavement is about 11 pesetas the surface meter.

In the new city, or "ensanche," the streets are of great length and of a width that is never less than 20 metres and that attains sometimes 30, 50, and even 60 metres. In fact they compare favorably with the very finest streets in the world. The pavements laid there are, for reaosns of economy, made from stone brought from the neighboring quarries of Montjuich. The system employed is that of macadam. As all the finest residences of Barcelona are in the "ensanche," and as it is growing rapidly in extent and beauty, doubtless the finest modern pavements will soon be demanded by the people there and substituted for the macadam pavements, which are not altogether satisfactory to those who cultivate nerves and aspire to repose of manner and speech. As a rule the streets of the entire city of Barcelona compare favorably with those of the other large cities of Spain. One million three hundred thousand pesetas are expended annually in the maintenance of old pavements, and 600,000 pesetas in the construction of new pavements, and yet the authorities are not satisfied with the work done. They recognize the fact that a civilized people should be satisfied with only the perfection of pavement.

HERBERT W. BOWEN,
Consul.

UNITED STATES CONSULATE,
Barcelona, January 10, 1891.

CARTHAGENA.

REPORT BY CONSUL MOLINA.

CITY STREETS.

Carthagena and Murcia are the only towns in this province and district in which any care is taken to improve the street pavements. It is only 16 years ago that the municipalities began paving the principal streets without any difference as to those of light and heavy traffic.

The streets in this town and in Murcia are laid with pavement blocks of gritty stone of an excellent quality from quarries near Valencia. The blocks measure 13½ inches in length by 6¾ inches in width by 6 to to 6¼ inches in depth. They are badly cut, having an exaggerated wedge form, the bottom face looking very reduced, and for this reason they can not be laid on sand as are the well cut stone blocks in the streets of Madrid and other places. Here they are laid in mortar, *i. e.*, a mixture of clay and sand with which the joints are also filled up.

There is no sort of foundation used but the natural substratum, which is previously leveled and rammed, it being so soft that the heavy traffic streets are full of hollows shortly after they are paved.

The cost of the aforesaid blocks free and ready in Carthagena per square meter (equal to 10.76 square feet) is from $1.40 to $1.80, the cost of the labor and other materials being from 30 cents to 50 cents per square meter.

The Carthagena town corporation is, however, actually using as a trial in some of the heavy traffic streets paving stone blocks of other sorts and sizes, some imported from Belgium and made out of smelted slag from blasting furnaces, etc., and also blocks cut from limestone quarries in Mazarron, 16 miles to the west of this port.

The Belgian blocks measure 10.76 square feet for every 52 blocks, and they cost at this port $3.05.

These are laid, after the substratum is properly rammed, on sand covered with a very light mixture of one-fourth sand and remainder Portland cement.

Full cost of square metre, including labor, sand, and cement, is $4.

The footpaths or sidewalks are now built, in general, with bands or edges of square stones, and the remainder made as follows: First, a base, 2½ inches thick, of small gravel; second, on this 1½ inches of a mixture of mortar and gravel; and third and last, a finish of mortar, *i. e.*, mixture of Portland cement and sand of one-half to 2 inches thickness, which, in the shape of flag spotted stones, makes the pavement proper.

This pavement costs from 50 to 70 cents per square metre and is giving excellent results.

The maintenance, however, of the streets is very much neglected, although great sums of money are spent thereon.

HIGHWAYS.

As it happens that the principal highways are constructed and maintained by the Government and the secondary ones by the provincial deputations, the municipalities therefore only takes care of the country roads, which, as a rule, are nearly neglected to the extent that transit is almost impossible in many of them, especially in winter. Most of the country roads are made only of natural trampling, whilst in others, near the towns, the rubbish is used, and in some small stones (if they are found near the place) are thrown over the surface in both cases.

With regard to the highways constructed by the Government, the substratum is composed of, first, 4 to 6 inches of lime or silicious stones, although sometimes all stones of sufficient hardness, broken over the very spots on which they have to be laid, to a depth of not over 2¾ inches; second, another layer of stone of 2 to 4 inches in thickness on the sides by 4 to 6 inches thickness on the center of the roads. These are broken outside until the largest of the stones reaches a dimension not exceeding about 1¾ to 2 inches, and afterwards laid on the first layer; third, land mixed with very small gravel to level the roads and fill up hollows is laid over all. The whole is then compressed by rollers. This operation is aided also, when practicable, by water.

The cost is very variable, according to the quality of the stone and the distances at which they are found; but the average price can be calculated thus: Collecting 1 cubic metre of stone found loose on the "ramblas" (dry river beds) or about the fields, from 10 to 15 cents; stones cut from quarries, 25 to 30 cents per cubic metre; cartage, 1 cubic metre of stone about 3 miles, 8 to 10 cents; breaking 1 cubic metre of stone for the first layer, 20 cents; breaking 1 cubic metre of stone for the second layer, from 25 to 35 cents.

CIRILO MOLINA Y CIRO,
Consul.

UNITED STATES CONSULATE,
Carthagena, January 10, 1891.

DENIA.

REPORT BY CONSUL MALMROS.

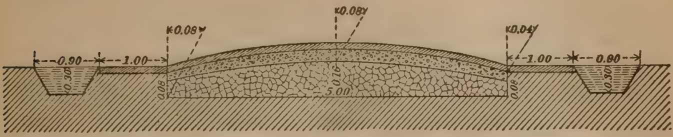
STREETS.

The streets of Denia and other towns in this consular district are common mud streets, unprovided with pavements, gutters, drainage canals or substructures of any kind, except such as unassisted nature has furnished. The only attempt made to improve the streets consists in occasionally dumping into them some cartloads of rocks of all sizes, from that of a human head to that of a walnut. The condition of the streets consequent upon this treatment is such that this kind of improvement, if such it may be called, can not be recommended as an example to be followed elsewhere.

IMPROVED COUNTRY ROADS.

A macadamized road leads from Denia to the town of Ondara, whence it branches off into three different directions. This road is 5 metres wide, with a sidewalk on each side of 1 metre wide, flanked by ditches of 0.90 metre in width.

The following plan of a cross-section of the road shows its construction and the dimensions of its several parts. It is taken from a portion of the road 1 kilometre in length, of almost perfectly level surface and possessing no features entailing extra expenses, as, for example, for bridges.



Plan of a cross-section of the road from Denia to Ondara.

After the excavation for the road has been made, as above indicated, and the ground been firmly beaten down, the first layer of stones is put on consisting of irregularly broken-up stones of from about 5 to 7 centimetres on the longest side. The second layer consists of the same kind of stones, but of smaller size, being from 3 to 5 centimetres long on the side of their greatest dimensions. These two layers are each 5 metres wide, while the third or top layer, extending as it does over the sidewalks, as well as over the road proper, is 7 metres wide. This last layer is composed of, as nearly as may be, equal parts of coarse, sandy gravel and of clayey soil. The quantity of stone and gravel required for the construction of the above-mentioned 1 kilometre of road is, from the dimensions given in the "plan," a matter of easy calculation for those interested in the subject. The stones and gravel of which this portion of the road is constructed had to be brought from an average distance of 3 kilometres. The cost of transportation of these stones and of the gravel has amounted to 1.25 pesetas per cubic metre, for each kilometre of carriage. The cost of the stone, unbroken, has likewise been 1.25 pesetas per cubic metre. The expense of breaking the stones is mentioned below in the list of wages paid. The cost of the gravel has been .37½ pesetas per cubic metre. The number of laborers employed in the building of said 1 kilometre of road has been different at different times, but the expense on account of the aggregate days' wages paid to each class of workmen has been as follows:

	Pesetas.
1,927 days' wages to common laborers, at 1.75 pesetas	3,372.25
675 days' wages to boys, at 1 peseta	675.00
1,399 days' wages to stone-breakers, at 2.25 pesetas	
135 days' wages to heads of gangs of 10 or 12 laborers, at 2 peset	
214 days' wages to heads of gangs of 10 or 12 laborers, more at 2.50 pesetas	
117 days' wages to chainbearers and flagmen, at 3.50 pese	
25 days' hire of roller, at 12.50 pesetas	
484 days' carts' (2 horses) hire, at 8 pesetas	

The 12.50 pesetas for hire of roller above mentioned is, more properly speaking, paid for the 3 or 4 horses and for the men working the roller, for the latter belongs to the Government and has been lent free of charge.

All of the above-named different classes of laborers work, according to the custom of the country, from sunrise to sunset, having an hour's rest in the morning for breakfast, and during the long days, *i. e.*, from May 3 to September 15, 2 hours' rest for dinner; also, in the afternoon one-half hour for luncheon. During the remaining part of the year there is only 1 hour's rest for breakfast and 1 hour's rest for dinner, and none in the afternoon for luncheon.

Experience in this and adjoining provinces has shown that one laborer for each 2 kilometers of macadamized road is sufficient to keep it in perfect repair. This laborer receives a small cottage on the road in which to live, free of charges of every description, and a common laborer's wages during the days he works on the road. He has to work on all days not legal holidays whenever the weather permits work to be done in the open air. The 7 kilometers of road between Denia and Ondara, however, have to be kept in repair by a single laborer, and the consequence is that this road is in a by far worse condition than any macadamized road I have ever come across, and I have seen such roads in every European country except Portugal.

One cubic meter of broken stone is here considered all that is required to keep in good repair during the year a decametre of a road on which an average traffic is carried on. On roads of unusually heavy traffic 1½ cubic metres of stone might be required. The stone used here for macadamized roads is a fairly hard limestone. If hard granite or some other rock harder than limestone were employed the quantity necessary for repairs would of course be less. As bearing upon the question of repairs, I may mention that the wheels of the carts in which freight is transported are here considerable broader than the wheels of wagons used for such purposes in the United States, and therefore do not cut up the ground to the same extent.

The construction of macadamized roads in this part of Spain has greatly benefited commerce, but its principal effect has no doubt been the increased value of land in the farming districts through which the roads run. I have been assured by persons of undoubted competency that farms adjoining such roads have in consequence of their construc- ... risen from 20 to 45 per cent. in market value.

OSCAR MALMROS,
Consul.

...NSULATE,
..., *June* 23, 1891.

GRAO OF VALENCIA.

CITY STREETS.

The streets are paved with hewn stones (psamita micacea) 34 centimetres long, 17 centimetres broad, and 15 centimetres high, which are brought from the mountains about 15 kilometres distant from this city; the cost of these stones to hew, bring and locate them results at pesetas 9 (about $1.50) per square metre.

The soil of this city is mostly soft earth; in building the street, the soil is simply excavated to 20 centimetres depth and the stones placed directly on this ground, allowing 1 per cent. curve on the width of its superficies for the water to run off; the result of this system with a considerable traffic of carts and carriages on them is pronounced satisfactory and the cost of maintaining is 10 centimos (about 2 cents) per square metre.

COUNTRY ROADS OR HIGHWAYS.

These are generally built in this province after the Macadam method. There are roads of first and second order connecting large cities of the country and constructed by the government; roads of second and third order connecting the villages with the capital at the expense of the province, and lastly suburban roads of the fourth order built by the municipality.

The stones used for the two latter kinds of roads here are mostly limestones brought from a distance of about 4 kilometres, and cost for bringing, cutting, and locating 1.50 pesetas (about 30 cents) per square metre.

These broken up stones are placed 25 centimetres high on the road and pressed down by steam rollers.

The cost of maintaining varies according to the distance or proximity of the road to the city and the greater or lesser traffic in these different places; but, in general, the soft character of the limestone and the soft subsoil on the one side as well as the enormous traffic on the other side, this method has given little satisfaction, and new systems are constantly studied.

STEEL RAIL ROADWAY.

Mention might be made of a trial of laying a kind of flat rails, which, after a practice of 1½ years on a short distance of the road leading from the city to the port, have given excellent results, and the city has now decided to build a double track on the entire road of 3.50 kilometres, considering the uninterrupted traffic of heavily laden freight carts between the port and the city.

This track is made of ordinary steel flat-top rails of this  shape, and placed without further foundation, always two together, in the soil, united with screws.

They have 22 centimetres superficie on a level with the road, but an indent of about 3 millimetres is allowed where the two rails join, for keeping the cart wheels easier on the track. The distance between the two iron tracks is 1.24 metres, roadway between which can be paved with flint stone at regular intervals. A plain steel used as cross-bar keeps the rails in their proper distance from each other. The road is 3.50 kilometres long and 12 metres wide; it will have on one side an up and on the other side a down track.

The cost of this track of imported steel rails is calculated at 50 pesetas (about $10) per running metre located and finished for use. So far the trial piece has been in use for 1½ years without any further expense for maintenance.

THEODOR MERTENS,
Consular Agent.

UNITED STATES CONSULAR AGENCY,
Grao of Valencia, December 22, 1890.

MALAGA.

REPORT BY CONSUL NEWSON.

In this section of Spain but little attention is paid to streets. Some in this city are macadamized, some are paved with syenitic blocks, a species of granite, and one street has the Nicholson pavement. The roads in the country are generally narrow, traveled mostly by donkeys, and but little cared for. The most popular mode is macadamizing. Some of these roads are very good, especially that leading to the lighthouse.

T. M. NEWSON,
Consul.

UNITED STATES CONSULATE,
Malaga, Spain, February 6, 1891.

GIBRALTAR.

REPORT BY CONSUL SPRAGUE.

There are no country roads in Gibraltar; the Rock is only 3 miles in length, its greatest breadth three-quarters of a mile, and its circumference about 7 miles.

Its acreage (including the north front, which is chiefly used for a parade ground) is about 1,266 acres, of which about 22 acres (public property) are reserved as garden ground.

By this it will be clearly seen that very little information can be obtained here likely to prove of any utility for the purposes required by the circular in question.

The streets, public thoroughfares, and walks in this British fortress, and what relates to their repairs, besides keeping them in order for general traffic, are entirely governed by the local government, who from time to time appoint sanitary commissioners to act as such, being composed of a few British officers and several members of the civil community of Gibraltar.

But few public buildings exist in Gibraltar, except military quarters and barracks, which are under the immediate supervision of the royal engineer department.

The streets and roads are somewhat inconveniently narrow and are chiefly made from limestone, which is obtained from the quarries on the north side of the rock, where the stones are broken and prepared for use as shingle before being brought into the town for macadamizing most of the roads and some of the streets, by being mixed with cement, gravel, and sand previous to being laid down, adding on some occasions, as required, granite shingle imported directly from Scotland, thereby forming with water a species of very solid concrete.

They prove to be the most handy, economical, and durable kinds of pavement for this climate, though requiring constant irrigation to lay the dust during dry weather.

Three of the principal streets, however, are paved with wooden blocks and cement, greatly facilitating general traffic, but its excessive cost prevents its more extensive adoption.

Heavy traffic is conducted by wagons and truck carts drawn by mules, and the light traffic by cabs and by means of small hand carts.

The cost of building road and street pavements is as follows:

For heavy traffic.—Wood blocks on a base of cement concrete, $5 per superficial yard; cement concrete in granite shingle, 6 inches thick on a bed of lime concrete and limestone shingle 9 inches thick, $2 per superficial yard; metaling in granite shingle (upper portion), $1 per superficial yard.

For light traffic.—Metaling in limestone shingle, 60 cents per superficial yard; pathways in cement concrete with fine limestone shingle, $1 per superficial yard.

HORATIO J. SPRAGUE,
Consul.

UNITED STATES CONSULATE,
Gibraltar, December 11, 1889.

SWITZERLAND.

REPORT BY CONSUL CATLIN, OF ZURICH.

It may with safety be stated that in no country in the world is the construction of roadways carried out with more scientific skill and thoroughness than in Switzerland. The mountainous nature of the

country, the consequent difficulty of providing means of easy communication between points located in comparative proximity to each other, and the severe tests to which roads, even when once constructed, are subjected by the violence of storms and the sudden swelling of water courses, have from the earliest period rendered the subject of road building one of primary importance to the dwellers in the Alps. It is a curious tribute to the skill and intelligence of the Romans that, in locating their Alpine roads, they followed precisely the methods recognized as best by road builders of the present time. They seldom, and then only in case of need, built a road far down on a mountain side; they followed the sunny side of the mountains, accommodated themselves to the lay of the land, and avoided great valley crossings, thus greatly diminishing the cost of the roads, and, what was to them of the greatest importance, remarkably facilitating their maintenance. Upon this plan they constructed the St. Bernhard, Simplon, Luckmanier, Bernardin, Spluegen, Septimer, and Julier roads, all of them well-known routes at the present day.

Nor were the Roman valley roads through Switzerland less judiciously laid out or less thoroughly constructed, for they coincide in the main with the leading railway or post routes of the present time. The principal ones were (1) Vevey to Solothurn to Basel; (2) Vevey to Geneva; (Gex to Payerne to Avenches, with six branches; (4) Basel to Windisch (Vindonissa) to Baden to Winterthur to Arbon (Lake of Constanz) to Bregenz; (5) Windisch to Zurzach; (6) Windisch to Solothurn, (7) Chur to Maienfeld to Vaduz to Feldkirch to Bregenz; (8) Ragaz to St. Margrethen; (9) Zurich (along the Lake of Zurich and the Wellenses) to Ragaz and over the Kunkel Pass to Reichenau.

For nearly 2,000 years these roads served as the means of international communication between France and Germany on the one hand and Italy on the other, inasmuch as up to the eighteenth century, no great changes in or additions to them had been made. During the Middle Ages the Graubuenden passes, and preferably among them the road over the Septimer, were used. The St. Gotthard Pass is first mentioned in the fourteenth century. Up to the end of the seventeenth century not one of the roads leading over the Swiss Alps was in condition to be ridden over in an unbroken journey for its entire length. In 1696 an important era in Swiss road building was ushered in by the first use of blasting powder on the roadway over the Albula Pass, but it was not until the middle of the eighteenth century that a systematic effort was begun to put the Alpine roads once more in an adequate state of repair. The rivalry of the newly developed roadway over the Mont Cenis conduced somewhat to its activity. Toward the end of the same century France turned its attention more closely to the Simplon route as well. The latter roadway was a great saving of time and distance, for it had already happened that merchandise from St. Gallen, destined for Turin, had to be sent by the long roundabout way of Geneva and Mont Cenis.

From the middle of the eighteenth century on there is also noticeable a revived interest in road building in the interior of Switzerland. In 1740 Berne inaugurated a series of fine roadways, varying from 10 to 12 metres in breadth, viz: (1) Berne to Zurich; (2) the Kystenstrasse via Burgdorf; (3) Berne to Solothurn; (4) Berne to Basel; (5) Berne to Thun; (6) the Aargauerstalden, and (7) the Muristalden. Up to the end of the last century Zurich could only point to four turnpikes worthy of the name, viz: Those leading to Schaffhausen, to Baden, to St. Gallen (via Winterthur), and to Frauenfeld. Between 1774 and 1778, Canton St. Gallen constructed her first great roadway, leading from Staad on Lake Constance, through the town of St. Gallen, to Wyl; this she followed up somewhat later by constructing the Toggenburger pike. Canton Thurgau constructed between 1776 and 1781 the first roadway from Frauenfeld (its capital) to Mazzingen, from Mazzingen to Wyl and Elgg, and from Islikon, through Frauenfeld, to Constance. Canton Basel, to which broad pikes from Germany and France gave access, continued the same onward into the interior of Switzerland in four lines, viz: (1) Along the Birs to Neufchatel; (2) over the Boetzburg to Brugg; (3) by way of Olten to Lucerne, and (4) to Solothurn and Berne. These thoroughfares were practically the only means of intercommunication in Switzerland during the better part of the last century. If they seem sparse and inadequate, it may on the other hand be stated that Switzerland was in this respect no worse off than the other European countries of that day, England not even excepted. The slowness of Europe's reawakening from the long night of the Dark Ages is perhaps nowhere more noticeable than in this regard.

But from the commencement of the present century, Switzerland has been making up for lost time. According to the estimate of Mr. S. Bavier, Swiss minister to Italy, who. in 1878, published a most interesting work entitled "Die Strassen der Schweiz," and from which the historical facts herewith given are derived, there were at that time 13,500 kilometers (8,388 miles) of turnpike roads in the country, or about 3 miles of road to every thousand of population. With justice, Mr. Bavier observes that Switzerland's network of highroads extending even to her remotest valleys, constitutes the pride and glory of the land.

The canton of Zurich is no exception to this rule. Her public highways are models in every respect, as every stranger, who has ever passed over them, whether on foot, on bicycle, or in vehicle, will readily testify. The cantonal law pertaining to the construction and maintenance of these highways gives such a clear insight into the subject that I have deemed it best to translate the greater part of it and to incorporate it herewith, viz:

LAW OF JANUARY 1, 1871, CONCERNING HIGHROADS.

I.—CLASSIFICATION OF ROADS.

(1) The public roads of the canton of Zurich shall be divided into three classes:

To the first class (turnpikes) belong those roads which serve as means of communication between the larger sections of the canton, embracing several townships, or connecting with similar roads in adjoining cantons.

To the second class (connecting roads) belong those roads which serve to connect the chief sections of a single township with each other, or with first-class roads, or with railway and steamboat stations.

To the third class (side roads) belong all those roads not embraced in the first and second classes, as well as all public footpaths.

(2) The following authorities are competent to take action with regard to classification, construction, and repairs of roads (with reserve as to Sections 5 and 6 of Art. 31 of the constitution (viz: For first class roads, the cantonal council; for second class roads, the district council, subject to the cantonal council's approval; for third class roads, the township.

Where several townships are concerned in the case of a third-class road, and no understanding can be reached, or when the minority in any township feels that its rights are infringed upon, the decision of the point in dispute rests, in the first instance, with the district council.

No decision shall be made except after a technical examination of the project, and, in the case of first and second-class roads, the wishes and views of the interested townships shall be heard.

(3) The classification of roads shall be subject to revision every 10 years.

II.—OBLIGATIONS CONCERNING THE CONSTRUCTION AND MAINTENANCE OF ROADS.

(4) The construction and maintenance of first-class roads pertain to the canton, excepting the transportation of the materials (earth not included) necessary thereto, the removal of rubbish, the clearing away of snow, the employment of assistant workmen, and the putting up of guide-posts and snow-marks, all of which services pertain to the townships.

(5) The construction and maintenance of second and third class roads pertain to the townships through whose jurisdiction they pass.

(6) The canton, however, in the case of second-class roads, undertakes, at its own expense, the preliminary technical work and superintendence of construction, and pays, in addition, a contribution to the cost of the same. This contribution (with reserve as to the exception mentioned in paragraph 8) may vary from one-sixth to one-third of the cost, and shall be fixed by the government council according to the importance of the road and the financial capacity of the townships concerned.

The canton shares in the cost of maintaining second-class roads by paying for the requisite road-keepers.

Where a township is either not traversed at all by a contemplated second-class road, or is only traversed by it to a slight extent, and yet it is to derive an actual benefit from the said road, it may be held responsible by the district council for a proportional share of the cost of its establishment in a neighboring township, with the right to appeal to the government council.

(7) The canton shall pay proportional damages to the townships in which second and third class roads are to any extent injured by the hauling of wood from the cantonel forests, or by the working of cantonel mines.

(8) In the case of first and second class roads laid out with sidewalks, pavements, gutters, etc., the excess of cost for construction and maintenance falls to the expense of the townships concerned.

(9) When the legal requirements upon any township prove, in consequence of special conditions, exceedingly burdensome, they are to be proportionally lightened by the canton.

(10) Private obligations hitherto in force with regard to the construction and maintenance of roads and bridges shall remain so, but may be commuted on demand of the parties concerned.

III.—DIRECTIONS FOR THE CONSTRUCTION AND MAINTENANCE OF ROADS.

(11) The width of driveway, with footway, shall be, for first-class roads, not less than 18 feet (5.4 metres); for second-class roads, not less than 15 feet (4.5 metres); for third-class roads, not less than 12 feet (3.6 metres). In each individual instance the width of a road shall be fixed accordingly to the requirements of the case by the competent authorities.

The area of the roadway shall, in addition to the road itself, include a width for slope, ditch, or border on each side as follows: For first-class roads, not less than 3 feet (0.9 metre); for second-class roads, not less than 2.5 feet (0.75 metre); for third-class roads, not less than 2 feet (0.6 metres). Exceptions to these rules may be made in the case of first and second class roads by the government council, and in the case of third-class roads by the district council.

(12) On straight or slightly-curved stretches of road the surface is rounded; on heavy curves there is an inward slope of at least one one-hundredth of the width.

(13) The actual roadway must, for first-class roads, be at least 15 feet (4.5 meters), and for second-class roads at least 12 feet (3.6 meters) wide, and must consist of a thick layer of stone at least 1 foot in depth. The upper stratum of this layer must be at least 3 inches (0.09 meters) deep, and shall contain no stones of over an inch and a half (0.045 meters) in diameter. Fine gravel shall be used for the footpaths on each side of the roadway.

(14) When the adjoining land does not lie at least 1 foot (0.3 meter) below the level of the border of the road, side ditches or paved borders are to be placed.

(15) Earthen slopes, at embankments, or cuts must be at least 1 foot in measurement (with an inclination of not over 45 degrees).

(16) At dangerous points the roads must be provided with fences.

(17) The boundary of the roadway must be marked out. Each two opposite stones determine its width, inclusive of ditch or border. The boundary marks are to be placed along the roads at regular distances of not over 200 feet (60 meters).

(18) Guideposts shall be erected where two or more roads unite, and when a necessity therefor exists.

(19) In order that roads may be kept in a normal condition, they shall be, whenever necessary, covered with properly prepared gravel, a sufficient supply of which shall always be kept on hand. When tracks or ruts of any kind occur they shall at once be properly leveled off. For this purpose the necessary number of gravel-boxes shall be placed along all first and second class roads, but, as far as is possible, not in the interior of towns.

(20) Dust and mud are to be collected into heaps as it becomes necessary, especiallly before gravel is laid on, and are to be removed within eight days.

(21) With a view to the proper drainage of water, the sideditches and culverts shall always be kept open and clean.

(22) For the insurance and maintenance of traffic the roads shall be provided with timely snow-marks, and, after a heavy snowfall, at once cleared.

(23) Paragraphs 11 to 14, 17, 20, 21, and 22 do not apply to public footpaths.

POLICE DIRECTIONS.

(*a*) *Relative to territory bordering upon roads.*

(24) No permanent stream of water shall, without previous permission, be conducted to a roadway from any adjoining land, building, spring, etc. The drainage, or flow of suds into road ditches or borders, or the drainage of water upon the road itself, as well as any pollution of the same by rubbish, stones, and sweepage from houses or stables, etc., is prohibited.

(25) Live hedges shall not be planted nearer to the street boundary than one-half their height, and in no case nearer than two feet (0.6 metre), and shall not be allowed to overgrow said boundway. Other (so-called "dead") fencings may be placed directly outside the road boundway. In case, however, they are closed, as for instance board fences, walls, etc., and are over 4 feet (1.2 meters) higher than the roadway, they are to be set back from the boundary line the distance by which their height exceeds such measurement.

(26) Forest trees shall be placed not nearer than 12 feet (3.6 metres) nor fruit trees nearer than 8 feet (2.4 metres) to first or second class roads, and no tree whatever shall be placed nearer than 5 feet (1.5 metres) to a third class road. Along all roads the trunks of trees are to be kept free from overhanging branches to the height of 15 feet (4.5 metres). The regulation relative to live hedges applies to bushes and ornamental shrubbery, to which latter class also belong clipped dwarf fruit-trees.

(27) New buildings and fountains must be placed at least 8 feet (2.4 metres) back from first class, and at least 5 feet (1.5 metres) back from second and third class roads, and no portion of any building shall project over the road. The law relative to the cession of private rights may be applied for removing existing buildings and fountains to the distance stated.

(28) Open water-conduits, reservoirs, and manure heaps in the vicinity of roadways shall be properly covered or inclosed, and must not be placed nearer than 4 feet (1.2 metres) to the road; likewise the unloading of manure, straw, wood, etc., within a less distance than 2 feet (0.6 metre) of the roadway is prohibited.

(29) In special cases, and particularly in those concerning the erection of rows of buildings, placing fountains, planting trees, etc., exceptions may be made by the direction of public works as for first-class roads, by the sheriff's office as for second class, and by the town council as for third class roads.

(*b*) *Relative to road limits, and their use.*

(30) A permit is required for any alteration in road limits, for filling in or covering of ditches for crossings, for placing culverts, borders, and conduit-pipes, and for the construction of the same. Such permits shall be granted by the direction of public works for first class, and by the town council for second and third class roads. A fee, to be fixed by resolution of the government council, may be charged for conducting water from private property across a road, said fee being payable to the cantonal treasury in the case of first class, and to the town treasury in the case of second and third class roads.

(31) The storing of materials of any kind on the public roads is forbidden. When the unloading of wood, stone, etc., on the road is unavoidable it must be done so as not to interfere with traffic, and the articles themselves, as well as the wagon, must be removed before nightfall. In extraordinary cases the unloading of building materials may be allowed by the town council for a period not to exceed fourteen days, subject to the regulations pertaining to the protection of traffic.

(32) Any act or contrivance jeopardizing road traffic is prohibited. The holding of markets within the road limits is only allowed in so far as it does not interfere with other traffic.

The local police is charged with the proper cleaning of the road, and with the repair of any damages thereto immediately after the close of the market.

(33) Riding and driving on the sidewalks adjoining the roadway (unless so ordered by requisite instructions to turn out), the driving of untied large cattle, the pasturing of stock along the borders of the road, the driving with fixed wheels without any wheel-shoe, the dragging of wood or stone, the use of plows too near to the side ditches or slopes, the damaging of boundary marks, railings, guide-posts, ornamental trees, etc., are prohibited. Furthermore, the leading or cleaning of plows on first or second class roads can not be permitted.

(34) No driver shall leave his draft animals untied, and none shall sit upon the wagon without having a sure rein upon them. On roads of less than 18 feet (5.4 metres) in width not more than two draft animals shall be harnessed abreast; in no case is it permissible to harness more than three abreast, or to attach two wagons together, excepting such as serve for agricultural work.

(35) Every vehicle shall turn out to the right for any other vehicle either approaching it from the opposite direction or driving up to it at a more rapid rate from behind. The driving of two vehicles abreast for any longer time than is required for one to pass is not admissible. Hand wagons are also subject to this regulation.

(36) At night every vehicle must be provided with a bell on the harness, or with a light; in the case of sleighs the former must also not be omitted in the daytime.

(37) Any vehicle or stock temporarily halted along the road shall be kept on one side so as to leave sufficient room for driving by.

(38) The width of empty wagons shall not exceed 7 feet (2.1 metres), and loads exceeding 9 feet (2.7 metres) in width can only be allowed in the case of materials the loading of which within a less breadth of space would be attended with unusual difficulty.

(39) Rapid riding or driving over bridges through narrow passages, at curves, and through inhabited towns, as well as the marching in step of a great number of persons over bridges, are prohibited.

(40) Wagons must be provided with wheels having tires of a width proportional to the largest loads admissible; two (or more) horse wagons shall not be loaded with more than 30 centners (1,500 kilograms) to each draft animal, and shall not have a less width of tire than 1 inch (0.03 metre) to each draft animal. The following are exceptions to the above rule, viz:

(*a*) Farm wagons used for carrying of goods or for harvesting crops.

(*b*) Vehicles for personal transportation or military purposes.

(*c*) Vehicles for the transportation of heavy objects which can not be taken apart, such as tree-trunks, stone blocks, pieces of iron, machinery, etc. Such vehicles must nevertheless have a width of tire of not less than 6 inches (0.18 metres).

(*c*) *Concerning public foot-paths.*

(41) The provisions of sections 24, 28, 30, 31, and 32 apply also to public foot-paths; on the other hand, sections 25, 26, and 27 may only be applied to the latter by special resolution of the competent authorities.

(42) Riding and driving on public foot-paths, as well as the driving of cattle on the same, in so far as it is not rendered necessary by unusual circumstances, are prohibited.

(*d*) *Penalties.*

(43) Disregard of the instructions contained in section IV will be regarded as trespass, and subject to a penalty of from 2 to 50 francs.

(44) Any one damaging a road is obliged to repair the damage or make compensation therefor.

(45) Owners of vehicles or driver of cattle are responsible for trespasses or damages caused by persons in their employ.

V.—SUPERINTENDENCE AND ENFORCEMENT.

(46) The chief superintendence of all matters pertaining to roads is vested in the government council, and under it, in the direction of public works to whom, outside of the district and the township authorities, the cantonal surveyer, the circuit surveyers, the overseer, and the road keepers are subject for the carrying out of the law. The government council shall, by promulgating the proper instructions, define more clearly the functions of the aforesaid officials and employés.

(47) The sheriff's offices have a general superintendence over all matters pertaining to roads, they watch over the fulfillment of obligations by the townships in regard thereto, and are in general charged with the enforcement of the law.

(48) Town councils are charged with the duty of looking after all matters pertaining to roads in their respective townships, as well as with the maintenance of the provisions for the policing of roads, and with the oversight of road-keepers on third-class roads. In cases where the town council does not possess adequate jurisdiction, it shall apply to the sheriff's office.

(49) When townships or private individuals fail to comply with any demand made upon them under the provisions of the present law, execution may be decreed at cost of the delinquent.

(50) Road keepers for first-class roads should be chosen by the direction of public works; those for second-class roads by the sheriff's offices, subject to approval by the direction of public works, and those for third-class roads by the town councils. The number and compensation of the same for first and second class roads shall be determined by the government council, and for third-class roads by the town councils.

(51) Town councils shall keep lists of all the public roads and footpaths within their respective townships.

VI.—IN RELATION TO CITIES.

(52) The cities of Zurich and Winterthur are charged with the laying out, repair, and maintenance of all streets within their respective limits. The canton contributes an amount not to exceed one-third toward the original construction or repair of such streets as are intended for through traffic, such amount to be proportioned according to the general importance of the street. But in estimating such cost of original construction, except in unusual cases, neither the expenses of expropriation or buildings, nor those outlays necessitated especially for city purposes, such as street pavements, sidewalks, drainage-sewers, etc., are to be taken into account.

* * * * * * *

(57) This law shall take effect May 1, 1871.

* * * * * * *

(58) The government council is charged with the execution of this law.

Zurich, Dec. 21, 1870.

In the name of the cantonal council.

R. ZANGGER,
President.
BOSSHARD,
Second Secretary.

Under the provisions of the foregoing law, a careful study of which in all its various details is commended to those interested in road building, the canton of Zurich last year operated 622.36 kilometres (386 miles) of first-class, and 744.21 kilometres (462 miles) of second-class roads, employing for the former 173, and for the latter 180 road keepers.

COST PER MILE PER ANNUM.

Now, taking for instance the first-class roads, it is of interest to ascertain what their maintenance cost per mile in dollars and cents for one year.

The outlays were:

	Francs.
Purchase of gravel bed	3,133.55
Uncovering and cleaning gravel	23,205.74
Bridges, sewers, and walls	18,137.48
Marks, signals, superintendence	9,803.55
Compensation paid to townships	18,633.20
Salaries and awards to road-keepers	79,378.80
Gross outlay	152,282.32
From which deduct for receipts	7,670.40
Leaving a net outlay of	144,611.92

For maintenance of 622.36 kilometres, *i. e.*, an outlay of 232.36 francs per kilometre, which is equivalent to 373.99 francs, or $72.18. This, of course, would be somewhat higher, however, than the average, as it includes the purchase of a gravel bed, the cost of which should, instead of being reckoned in any single year, be distributed over a number of years.

STREETS OF ZURICH.

It may be safely stated that in no city of the world are the streets more substantially constructed, more thoroughly and at the same time economically maintained, or more cleanly kept than in Zurich. Their neatness and cleanliness invariably excite the remark and elicit the admiration of the observant stranger. In order to give a general idea of the method of construction, materials used, etc., in the different kinds of streets, I have obtained from the city surveyor's office, and forward with this report, profiles of (1) an ordinary street in Zurich, (2) the Limmat Quay, and (3) the principal boulevard, the Bahnhofstrasse, universally admitted to be the finest street in any Swiss city. These profiles give in themselves a full and detailed description as to grades, measurements, materials, etc., and will be found of especial value to those technically interested in this subject. With a view to ascertaining further particulars relative to the cost of constructing and maintaining the streets of Zurich, I addressed a series of questions to the city surveyor covering the points stated in the Department's circular of inquiry, and have received very full replies thereto, which, with the questions, I append herewith.

According to article 53 of the cantonal law, said law, so far as concerns sections I to V, has no application to the cities of Zurich and Winterthur. The limit of public ground occupied by the streets coincides with the street borders, that is to say the street lines; embankments, in case there are such, lie on private ground. The building lines coincide, as a rule, with the street lines. In individual cases they lie further back, so that gardens may be placed before the houses. In the older quarters of the city the width of the streets has been handed down from former times. Newly laid out streets have a minimum

width of 12 metres, and, according to their importance, a width of 15 metres and upward. All streets have raised sidewalks with granite curbs. The center of the driveway is of the height of the curb, and slopes off, so that the surface lies 10 or 12 centimetres lower than the latter. The sidewalks have an inward slope (toward the street) of 5 per cent. The street is graded according to the land and to its own importance as a highway.

The street driveways are either (1) laid in concrete, (2) paved with stone, (3) or provided with pressed asphalt or (4) with wooden blocks. The sidewalks are of concrete, with either stone pavement, or with melted or pressed asphalt covering.

The cost of first construction is as follows:

Description.	Driveway (per square yard).	Sidewalk (per square yard).
	Francs.	*Francs.*
Concrete	3.34	2.09
Stone pavement	7.52	7.52
Melted asphalt	....	9.20
Pressed asphalt	12.87	9.36
Wooden blocks	12.29	....

The cost of annual maintenance is as follows: Concrete, 0.92 to 0.42 francs; stone pavement, 0.50 to 0.17 francs; melted asphalt, 0.42 francs.

It is to be assumed that the stone pavements of driveways must be renewed every 17 years, and the melted asphalt on the sidewalks every 10 years.

The street commission has thus far had no experience as regards the maintenance of pressed asphalt or wooden blocks, inasmuch as these latter have only been introduced of late years.

Formerly this work was charged to a special account, redeemable in 30 years, but now it is paid from the direct revenues of the city, consisting in the funds derived from real estate, capital, fees, and taxes.

Formerly all the streets in the interior of the city were provided with pavements of an inferior quality, which, however, about the year 1865, were replaced by new stone pavements, which still partially exist The newly constructed streets of the last thirty years or so, especially those in quarters of the city not so closely built up, are all provided with concrete driveways, and with paved crossings for pedestrians at the most frequented points. Pressed asphalt and wood blocks are put down in streets in which it is important to prevent noise and dust.

All sidewalks in the interior of the city are either paved or laid with melted asphalt; in the outer quarters they are mostly of concrete only. Pressed asphalt is only used on the sidewalks of the two principal streets of the inner city, namely, the Bahnhofstrasse and the Limmat Quay.

In the choice of either one or the other kind of construction for a street, reference is had more particularly to the amount of disposable funds rather than to the question of heavy or light traffic thereon.

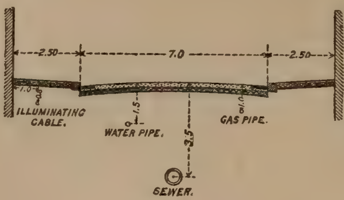
Unquestionably the condition of a street affects the adjacent property, and a good pavement certainly contributes more to values than where the street is merely laid in concrete. To what extent this exists it would, however, be difficult to give in figures; nothing has as yet been done here in such direction. It may only be mentioned that in laying down a raised sidewalk half the expense as well as half the cost of repairs must be paid by the owners of the property fronting thereon. This ordinance is embraced in the law of June 30, 1863, relative to the cities of Zurich and Winterthur. In the laying down of the newly widened Limmat Quay the property owners fronting thereon pay the difference between the wooden block pavement actually used and the stone pavement previously contemplated.

GEORGE L. CATLIN,
Consul.

UNITED STATES CONSULATE,
Zurich, January 20, 1891.

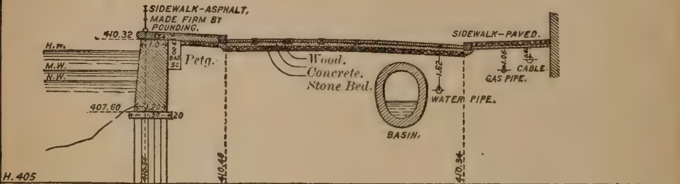
CROSS PROFILE, 1:100.

Street and Sidewalk Causewayed.



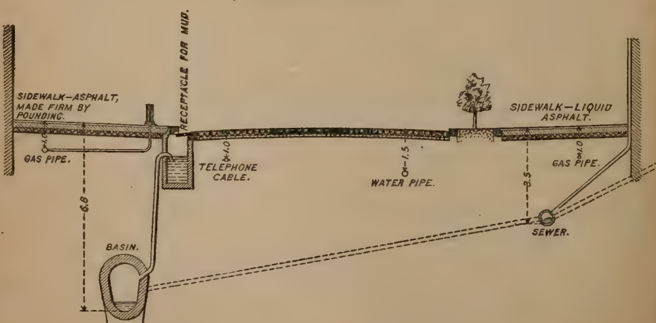
CROSS PROFILE OF THE LIMMAT QUAY, 1:100.

Street, Wooden Pavement.



CROSS PROFILE OF BRAHNHOF STREET, 1:100.

Street Paved.



SWITZERLAND.

REPORT BY CONSUL ADAMS, OF HORGEN.

ROADWAYS OF SWITZERLAND.

In any country the oldest artificial roadways are more recent than the original routes of migration, travel, and commerce. There is evidence of active intercourse along such natural routes between the primitive communities of Switzerland, Italy, and France for many centuries before the Christian era. What is now Lombardy was connected with eastern Switzerland by the Julier, Septimer, Splügen, and Bernadino passes, Piedmont with western Switzerland by the Grand St. Bernard, and the lake of Geneva with the Phœnician colony of Marseilles by a route following the Rhône Valley. This last line and the Grand St. Bernard were joined by another running from the neighborhood of Lyons over the Little St. Bernard to Aosta. All these routes differed from the local pathways leading from one camping ground or hamlet to another only as they were more frequented and therefore better trodden. The modern roadways of Switzerland, and of Europe generally, originated with the Roman engineers in the last century before Christ. Constructed in the first instance for the march of armies and the postal service of the empire, they were promptly occupied by the tributary commerce which poured into Italy with augmented volume as the dimensions of the empire increased. When the northern frontier was finally established along the line of the Danube and the Rhine, the Swiss roads acquired at once the character of transcontinental and international routes which they have retained ever since. Before the end of the third century two great systems of elaborately constructed highways connected northern Italy, across Swiss territory, with Gaul and Germany. In the west the Grand St. Bernard led from Aosta to Martigny, on the upper Rhône, where it was joined by the Simplon coming from Lago Maggiore; from Martigny the route was prolonged to Vevey, Soleure, and Augst, near Bâle, whence it descended the Rhine northwards into Germany. This great line sent off two lateral spurs into Gaul, one by Geneva and the lower Rhône Valley, the other by Poutarlier to Besacnon. In the east parallel routes led from the Italian lakes and Milan over the Splügen, Septimer, and Julier to Chur and the lake of Constance. The two systems were connected in the north by running from the upper Rhine and Lake Constance to Soleure and Bâle. These main lines threw out local branches to all the important towns and military stations of the country.

In the breaking up of society which followed the invasion of the barbarians and the fall of the Empire, the Roman roads, although in continued use, fell out of repair and finally into ruin; nor was any serious attempt made to restore or replace them until the modern communities of Europe were definitely constituted and brought into sustained

intercourse with one another. As the geographical center of the continent, Switzerland was one of the first countries to profit by the revival of the European movement. A new route was carried over the St. Gotthard in the twelfth century; the other passes into Italy, especially those diverging from Chur, on the headwaters of the Rhine, recovered something of their ancient importance; and the Julier in particular was improved to accommodate the oriental traffic which flowed through Venice until the discovery of the ocean passage by the Cape of Good Hope; much, too, was done to facilitate local communications between different parts of the country. But with all this activity and improvement the Swiss roadways remained everywhere in bad condition down to the end of the last century. Partly from faults of construction, partly from subsequent neglect, most of them were footpaths for pedestrians and pack-horses, and the best only admitted the passage of small vehicles solidly built and lightly loaded. To this are to be added the burdensome tolls and taxes in great variety exacted by the local communities, the last of which were suppressed by the federal government in 1848. In singular contrast with the immense development of architectural engineering throughout Europe during and since the Middle Ages, the Swiss roads are practically the creation of the nineteenth century.

The first great construction of the new era was the Simplon, begun in 1800 by the Emperor Napoleon and finished in 1804. The Simplon was followed by the Bernadino (1818–1821), the Splügen (1818–1823), the Julier (1820–1826), the Maloja (1827–1828), the St. Gotthard (1820–1830), the Furka, Oberalp, Albula, Flüela, Bernina, Offenberg, Lukmanier (finished 1876), and the Brünig. These great mountain roads, with the highways following the water-courses or traversing the lowlands, form the skelton of the system to which all the lesser local roads are attached. The system reached its full development between 1870 and 1880; for the last 20 years the energies of the country have gone mostly to the extension of railways. I subjoin a table giving the general statistics of the principal roadways for 1877, since when no important additions have been made to the literature of the subject. (Annex I.)

The Swiss roadways are almost entirely in the control of the several canton, and, under the cantion, of the several districts and townships. The federal government has declared all roads free for public use. It exercises a general supervision over post-roads, and, I believe, grants subsidies for the maintenance of such roads as have the character of international routes. But the building, the repair, and the police regulation of roads are in general left exclusively to the cantonal and local authorities. Yet the system is practically uniform throughout Switzerland, notwithstanding extraordinary differences in race, language, character, and usages between different parts of the population. This concordant action where great variety might be looked for, and long existed, is due to a fact without which this historical recapitulation

would lose much of its pertinence. The Swiss roadways of the nineteenth century are really a revival of Roman engineering; after centuries of mistaken experiments, a return by common consent to the Roman method of construction and the Roman selection of routes.

The Roman roadway, wherever necessary, had a carefully laid foundation of undressed stones, which was slightly convex or vaulted, and held by longitudinal borders of square stones, the whole forming a coherent and solid structure. The size of the stones so employed varied greatly in different localities according to the material available. In the great roadway of the western system traversing the lowlands between Avenches and Solothern, the foundation consisted of rolled and rounded stones, averaging 10.15 centimetres in diameter (see Annex II). On the south slope of the Septimer in the high Alps, the foundation was a compact masonry of angular stones from 0.60 to 1.50 metres in longitudinal diameter, carefully fitted together and held firmly by the pressure of the border blocks (see profile and ground-plan Annex III). On the stone foundation was spread a layer of gravel, usually mixed with argillacious sand as a binding material, and thoroughly stamped down as in our macadamized roads. This furnished a firm and smooth surface which shed the water and kept the whole structure dry (see profile Annex II). In lighter roads the gravel sometimes lay between two layers of common earth (profile Annex IV). In the Swiss roadways the depth of the structure varied from 0.70 to 1.30 metres; the surface width from 2 to 3.50 metres. The surface was sufficiently elevated to shed water, and even along mountain slopes the road-bed was let into the soil only on the upper side and only to the depth required by the conformation of the ground. The route kept, when possible, to the sunny sides of mountains, adapted itself closely to the natural curves of the surface, and avoided all avoidable cuttings, causeways, and bridging of gorges. It is upon these principles that routes, both of roads and railways, are laid out to day.

The identity of structure in the Roman and the modern Swiss roadways may be seen at a glance by comparing the Roman profiles with two others subjoined, taken from roads of the second and third classes in the canton of Bern (Annexes V, VI). The modern roadway is less solidly built, has a greater breadth (varying from 7.50 metres or more in roads of the first class to 4 metres or less in roads of the third class, and pays more attention to the lateral accessories for consolidating the adjacent soil and carrying off water. But the internal system of construction is the same in both.

Now the characteristic and essential feature of this system is the substructure of stone. It is never omitted in either the ancient or the modern roads, except where the natural foundation of the bed offers a sufficient substitute, as when the roadway is excavated in solid rock. *Ohne unterbau keine strasse* (without an adequate foundation there is no durable road). No matter on what system or with what care and ex-

pense the surface is treated, the result will be swift ruin unless the superstructure is properly supported from beneath. On the other hand, given the foundation, the surface may be treated effectively almost anywhere and adapted to any use; it may be formed of common soil if nothing better is available, or of gravel, or of both; it may be macademized or covered with any variety of pavement. The worst surface with a good foundation affords a better road than the costliest surface without a foundation. This is probably the most important lesson to be got from European experience in road-building.

It follows that in all mountain regions and in all lowlands which have been supplied by glacial action or the flow of water courses, with stones in abundance, good roadways are merely a question of time, money, and intelligence; any community may have them to the extent required if willing to pay for them. But for alluvial or deluvial soils, destitute of stones and gravel, as on the western prairies and in the valley of the Mississippi, the case is different, and little is to be learned from European methods of road building. The problem is surrounded by local difficulties which can only be solved on the spot, if at all.

To cover the inquiry submitted by the Department's circular of November 8, I will add, in conclusion, that in Switzerland city and suburban streets are only local adaptations of the ordinary roadway. Provision is made beneath the roadbed for drainage and the distribution of water and gas, and the surface, including the trottoir, is macadamized or paved in a variety of ways; but these are all external to the central structure, which is unchanged. For further details I refer to the report of the agent at Lucerne, with accompanying sections of streets and quays of the city.

LYELL T. ADAMS,
Consul.

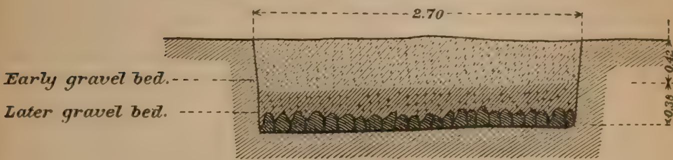
UNITED STATES CONSULATE,
Horgen, January 27, 1891.

Length and cost of the principal roadways of Switzerland in 1877.

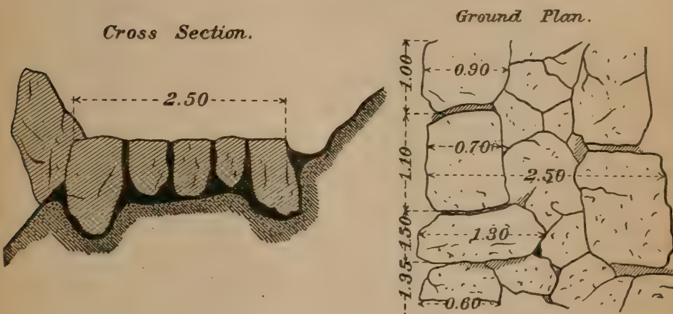
Superficial area of Switzerland .... sq. kilometres..	41,390
Population in 1870	2,669,147
Length of roads:	
Class I	6,548
Classes II and III	6,806
	13,354
Length of roads of all classes per sq. kilometre of area.. sq. kilometres..	323
Length of roads of all classes per 1,000 inhabitants........do....	5,003
Cost of construction of roads, Class I ....francs..	173,498,400
Cost of construction of roads, Class I, per sq. kilometre........do....	4,190
Cost of construction of roads, Class I, per 1,000 inhabitants........do....	65,000
Average cost of roads, Class I, per kilometre ....do....	26,480

This tables includes only roads whose widths is not less than 4.20 metres. The increase of roadways since 1877 has probably kept pace with the increase in population (estimated in 1888 at 2,934,000), so that the proportions remain about the same. Statistics of the cost of roads of Classes II and III for the most part built by the townships, are incomplete.

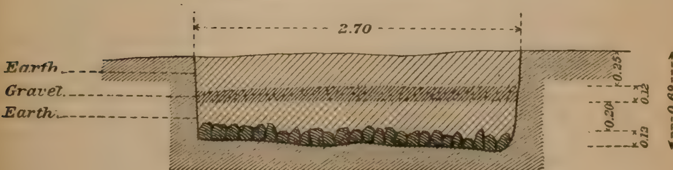
Roman road below Kallnach, between Grenches and Soleure.

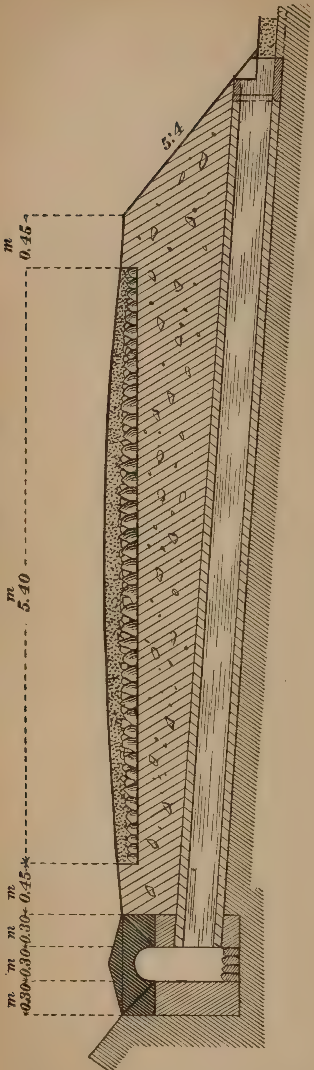


Roman road on the Septimer.

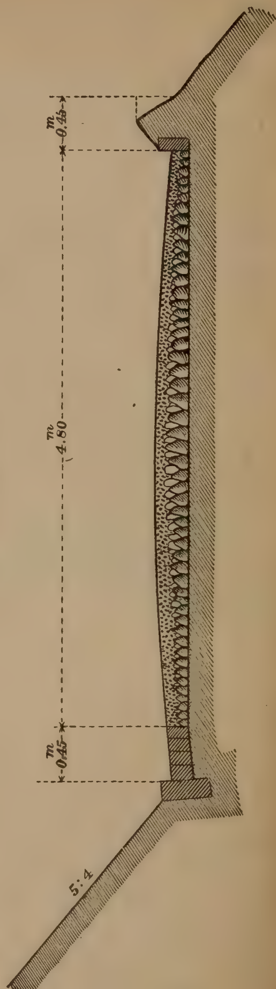


Roman road above Mett in the Jura.





Modern road, Class II, canton Bern.



Modern road, Class III, canton Bern.

CANTON OF BASLE.

REPORT BY CONSUL GIFFORD.

CITY STREETS.

The streets of the canton of Basle City were for the most part built in the last century, but have been several times improved in recent years. There is no division of these streets into classes, and the city, which embraces substantially the whole canton, builds and maintains the same at its own cost, with the exception of a few field roads. The length of the streets is 102 kilometres and the steepest grade admitted is 5.40 degrees.

The following information relates to streets built in late years:

Material and cost.—For the paved streets three different materials are used, viz, stone from the Rhine—so-called Rhine pebbles—quarry stone from Alsace, and wood. The cost of the Rhine pebbles is from $2 to $2.30 per cubic yards, that of the quarry stone, 3 cents for each block; the dimensions of which are 5 by 7 by 6½ inches. The wood for pavement of that material costs from $7 to $8 per cubic yard.

The stone pavement is from 4¾ to 5½ inches thick, laid on a sand foundation 2½ inches deep. When constructed of Rhine pebbles it costs 65 cents per square yard; when of quarry stone, $1.60 per square yard

The wood pavement is 4 inches thick on a beton foundation from 6 to 8 inches in depth. The cost is $2.50 per square yard.

Macadamized streets are laid on a limestone foundation 6 inches deep over which is a layer of broken stone rolled down with cement. A square yard of finished street costs from 45 to 50 cents. Along the sidewalks is constructed a paved gutter 3 feet wide, at an expense of 65 cents per square yard.

Sidewalks have a border, composed of strips of granite, 10 by 12 inches in size, costing $1.50 per linear yard. In the interior of the city these sidewalks are of Travers asphalt, four-fifths of an inch deep, laid on 4 inches of beton. In the suburbs the material used is gravel and sand. The cost of the former is $1.25; of the latter, 6½ cents per square yard.

The breadth of the streets is 10, 13, 16, and 20 yards, the sidewalks constituting one-fifth of the width in each case.

Maintenance.—The maintenance of the paved steeets is reduced to raising the sunken portions as required and the renewal of the pavement after the lapse of 15 or 20 years.

Each year the macadamized steeets are ballasted according to the wear to which they have been subjected. The material used for this purpose is for the most part broken stone; less frequently, round pebbles of the proper size. In both cases the stone is dumped in the street and left to be crushed by the passing teams.

The yearly expense of keeping a macadamized street in repair is $310 a mile.

The details of this very considerable expenditure are for the 102 kilometres of macadamized street in this canton as follows:

	Francs.
19 street surveyors	25,100.40
61 workingmen	32,732.30
7,017 cubic metres material	16,543.83
Cartage	17,483.40
Labor at gravel pits	2,337.80
Watering, etc	9,253.09
Total	103,650.82

Street Department.—The building and maintenance of the streets is intrusted to the building department of the cantonal government, the chief of which is a member of the executive council. The other officers of the department are the secretary, treasurer, a cantonal engineer, assistant engineer, and a road surveyor. The city is divided into nineteen districts, each of which is cared for by an assistant surveyor and 2 or 3 laborers. The cost of this department is $5,900 a year, exclusive of the salary of the chief and the wages of laborers.

GEORGE GIFFORD,
Consul.

UNITED STATES CONSULATE,
Basle, January 20, 1891.

GENEVA.

The roads in my consular district having been laid out by the ancient Helvetians many hundred years ago, are kept in order now simply by the addition of broken stone occasionally. Great age with the assistance of the broken stone have made the roads about as perfect as can be desired. The streets recently put down in the city of Geneva, were given out by contract to Americans who put down the modern block so well known at home.

ROLAND J. HEMMICK,
Consul.

UNITED STATES CONSULATE,
Geneva, December 23, 1890.

LUCERNE.

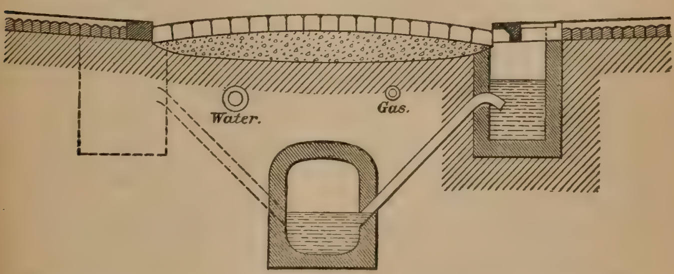
REPORT BY CONSULAR AGENT WILLIAMS.

CITY STREETS.

The city of Lucerne being very ancient, the streets are, as a rule, very narrow, but if they can not be improved so far as width is con-

cerned, they are kept in very good order. In the old part of the city the streets are paved with squared river stones of about 6 inches on each side. These are laid in regular courses, running across the roadway, and breaking joint with each other. The carriage way has a slight rise or convexity in the middle in order that water may run off it towards the sides. This convexity is from 2½ to 3 per cent. The footways are nearly level with the highest part or crown of the carriage way, and have a slope of 2 per cent. towards the carriage way. The curbstones are of granite, and now all the footways in Lucerne are finished with asphalt. The way of constructing these asphalt footways is as follows:

The ground is excavated to a sufficient depth, and then a foundation of stones, 6 inches high, is carefully laid by hand, and then covered with a layer 2 inches thick of concrete composed of cement, hydraulic lime, gravel, and sand. The concrete is properly smoothed and leveled and left some time to harden, after which it is covered with a layer of asphalt averaging three-fourth inch in thickness. Under the center of the carriage way, and at a depth of from 6 to 8 feet, runs the sewer or drainpipe, into which the water runs through the "gully holes," which are situated on each side of the roadway at distances of from 100 to 200 feet from each other, according to the gradient of the street. In order to prevent the escape of foul air through them, they are provided with siphon traps. The following section of a street shows the mode of construction.

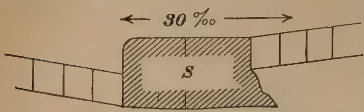


Formerly the footways were paved with small square paving stones, and there are still a few in the city, constructed in that way, but this system is now abandoned, as asphalt is found better in every way. A paved footway lasts about 15 years but it often requires to be releveled. An asphalt footway lasts about 20 years and if well made in the first instance requires little or no repairs.

COST OF PAVED STREETS.

(1) Cost of paving with well-cut river stones, including labor, per square metre, $1.16.

(2) During the last 20 years the streets of Lucerne have so often been cut up for the purpose of laying drains, water pipes, gas pipes, electric-light wires, etc., that it is impossible to give the cost of repairs.



(3) Granite curbstones for footways: Straight per metre, $1.06; curved, per metre, $1.26; laying curbstones, per metre, 20 cents.

(4) Paving footways with small squared stones laid in sand, per metre, $1.16.

ASPHALT FOOTWAYS.

Stone foundation, 15 centimetres high, covered with concrete, made of cement and hydraulic lime, 5 centimetres thick, per square metre, 48 cents. Asphalt, 2 centimetres thick, per square metre, 97 cents.

HIGHWAYS.

In the old diligence days the postal roads of Switzerland were celebrated, and although, since the introduction of railroads the same amount of care has not been given to the maintenance of highways, still I think that the Swiss postal roads would compare favorably with the roads of almost any other nation. I do not know if the system of construction is the same all over Switzerland, but probably it is so. In the canton of Lucerne highways are constructed in the following manner:

(1) If the road is in level ground, or nearly so, ditches are cut on each side, for draining. The carriage way, which is 9 metres, or thereabout, say 30 feet, wide, is not excavated, but leveled, some of the earth taken from the ditches being used to fill up the hollows. On this bed a foundation of stones 8 or 9 inches high is built, and on this a layer of large gravel, generally river gravel, is laid to fill up the interstices between the foundation stones; the size of the gravel used is about 2 inches. On this a little earth or sand is spread, and above it a thick layer of coarse gravel is laid. After this has become consolidated by the traffic, the road is kept in order by successive layers of gravel as required. In places where it is difficult to obtain river gravel, hard broken stones are used instead, something after the system of Mr. Macadam, except that a stone foundation is always used, which Mr. Macadam never made use of. When broken stones are employed it is necessary to loosen the surface of the road with a pick before the addition of each layer of material.

(2) When the road is made on a slope, a shallow ditch is cut on the upper side. The water runs in gully holes, and is carried under the road to the lower side by cement pipes, with an internal diameter of from 8 inches to 24 inches, according to the volume of water to be carried away. When the roads are made on mountain sides, where streams of water or small torrents come down from the heights, instead of pipes

a culvert is built of a size suitable to the requirement. In that case, the lower side of the road, instead of being an earthen embankment, generally consists of a retaining wall, well pierced with draining holes.

(3) All the roads have a convexity of about 4½ or 5 per cent. to enable the rain water to run off to the sides.

These high roads are very hard, and are soon dry after rain.

I inclose herewith four tracings of sections of roads in or near Lucerne, kindly supplied to me by the director of constructions of the city of Lucerne, which show clearly the method of road building.

COST OF HIGHWAYS.

(1) Stone foundation of rubble or river stones, not less than 8 inches high, per square metre, 39 cents; river gravel, from 2 to 2½ inches, per square metre, 5 cents; broken stone, 6 to 7 cents.

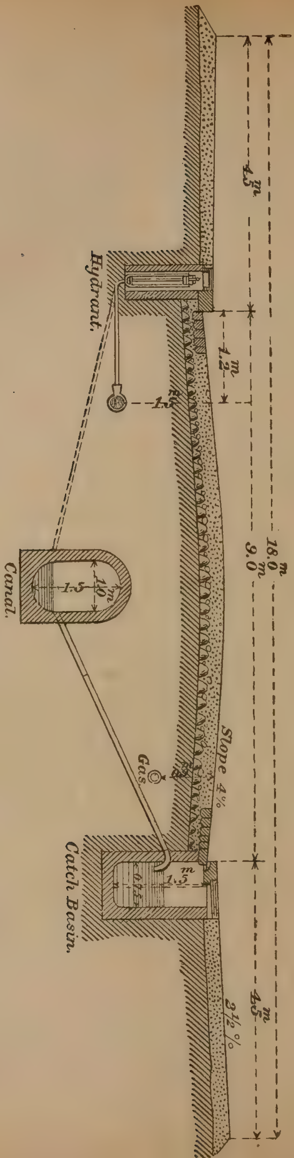
The price of maintenance varies, as is shown by the following figures: 1875 (great activity in construction) cost, per square metre, 4 to 5 cents; 1881 (works suspended) cost, per square metre, 2 to 3 cents; 1890 (great activity) cost, per square metre, 3 to 4 cents; broken stones delivered on road cost, per cubic metre, $1,31. River gravel delivered on road cost, per cubic metre, $1.04.

EFFECTS OF IMPROVED HIGHWAYS.

With regard to the effect of improved public roads upon land values in the country, I am unable to speak, but in the neighborhood of the city it is estimated that an improved carriage way augments the value of lands through or near which it passes from 6 to 12 per cent. When an improved road near the city is required it is customary for the proprietors, through or near whose land the road is to pass, to petition the city council. If it is decided that the road be made, the municipality undertakes to get the plans made by its own engineers, and to have the road constructed. It also pays one-third of the cost of construction. The remaining two-thirds are paid by the proprietors, in proportion to the extent of their land and its nearness to the road. The proprietors have also to pay to the municipality a yearly tax for the maintenance of the road, but they have the option of redeeming it by one payment. The roads being maintained by the municipality are always kept in good order.

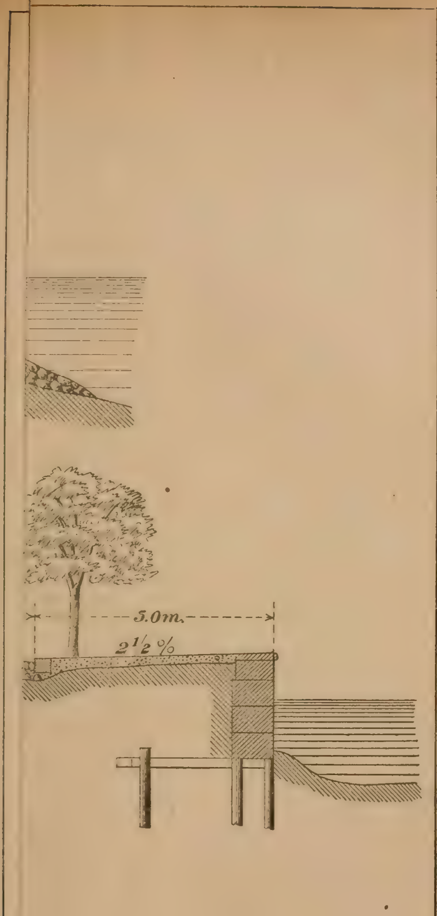
ERNEST WILLIAMS,
Consular Agent.

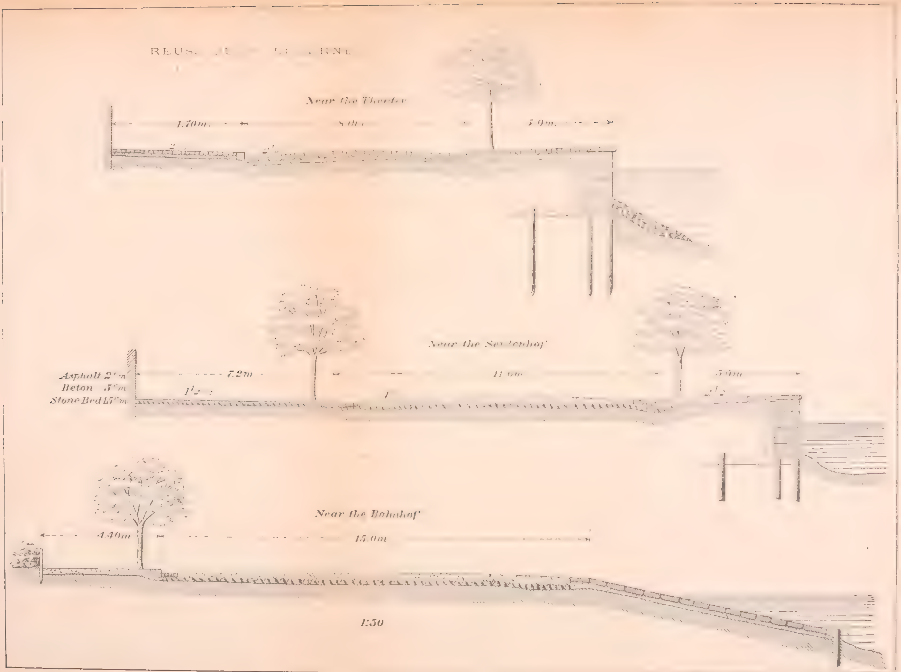
UNITED STATES CONSULAR AGENCY,
Lucerne, January 5, 1891.



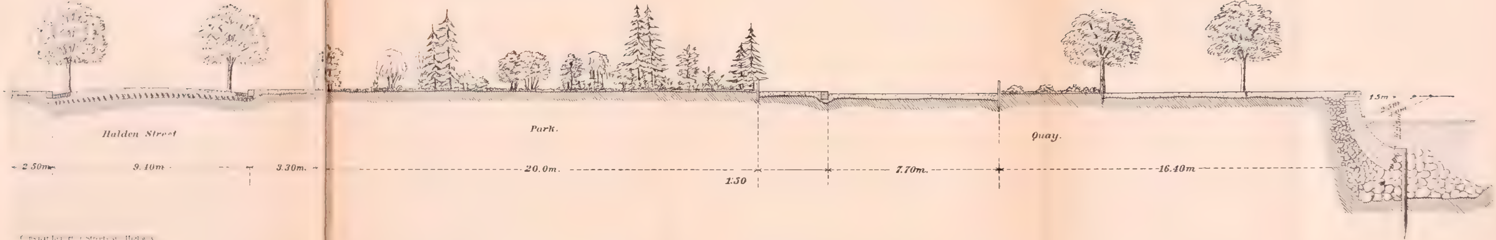
1:50

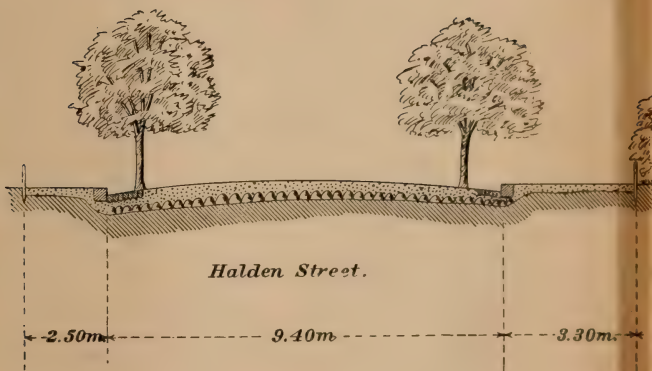
Hirschmatt street, Lucerne.


5.0m.
2½ %


Near the Theater
1.70m.
5.0m.
Near the Bahnhof
4.40m
15.0m
Asphalt 2cm
Beton 5cm
Stone Bed 15cm
7.2m
1:50

NATIONAL QUAY AND HALDEN STREET, LUCERNE.

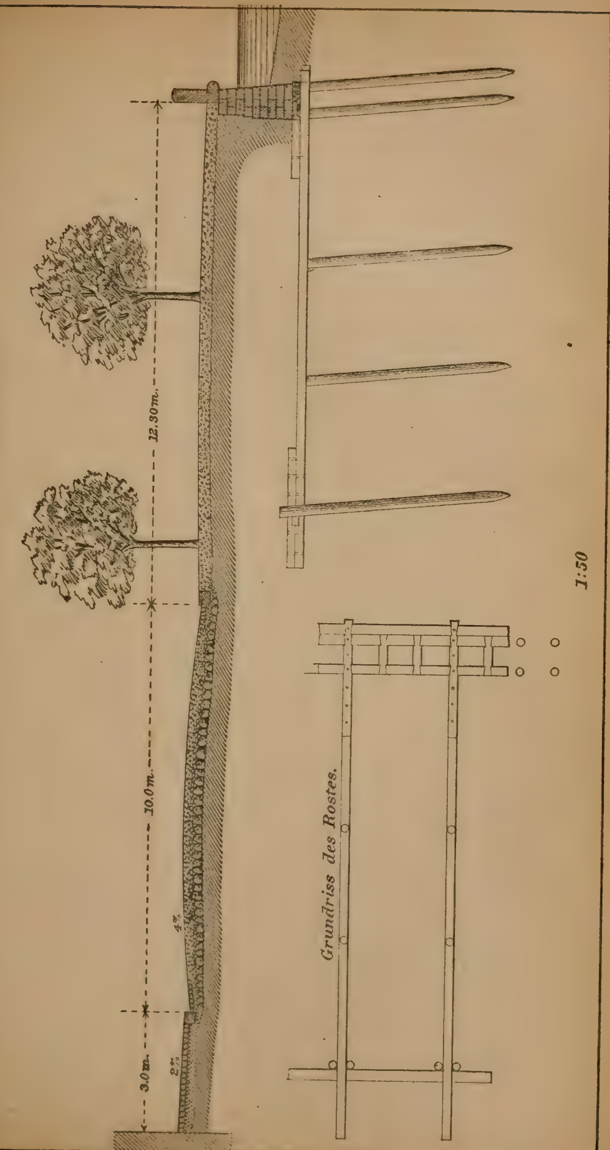




Consular Report on Streets and Highways.

24

SCHWEIZERHOF QUAY, LUCERNE.



CANTON OF ST. GALL.

REPORT BY CONSUL ROBERTSON.

STREETS.

The streets of the city of St. Gall are surprisingly bad, when it is considered how constantly they are being worked upon, cleaned, repaired, etc. With this, however, the large falls of snow and rain and the general climate here have much to do.

The laws governing the building inspection and repair of the streets are strict and strictly enforced.

The making of the streets is given out by the municipality either to regular employés, and under municipal direction and supervision or to outsiders under contract according to regular specification, general rules, and estimates. The latter plan is generally preferred. The streets are either macadamized or paved, and the sidewalks macadamized, paved, asphalted, cemented, or tiled.

One kilometer of macadamized street, 12 metres wide, with two gutters, and sewers underneath these gutters, will cost 22,000 to 55,000 francs, and the sidewalks per square metre as follows:

	Francs.
(*a*) Macadamized with stone bed and covered with gravel	3 to 5
(*b*) Smooth paved	10 to 25
(*c*) Asphalted	20 to 30
(*d*) Cemented	18 to 32
(*e*) Tiled (plates of Sinzinger material)	18 to 32

The building of streets with sidewalks, gutters, sewers, etc., raises the values of the adjoining properties from 3 to 10 times over original ones, and in somes places even as much as 30 times.

Streets of the so-called first class which are used by heavy teams receive a quarry stone bed from 15 to 30 centimetres thick, and a covering of river gravel from 10 to 15 centimetres thick. Those of the so-called second and third classes which are used for light teaming receive a stone bed of quarry stone from 10 to 18 centimetres thick, and a covering of river gravel from 6 to 10 centimetres thick. For the stone bed is used only very hard sandstone (gray-blue sandstone). Gravel is sometimes used as a concrete. For covering streets there is generally used river gravel mixed with some sand. Sometimes, to save expense, quarry gravel is used.

The sidewalks are built in the same way as the streets, only that the concrete will be but from 6 to 8 centimetres thick, and the covering of very fine gravel, from 3 to 4 centimetres thick.

A square metre of street stone bed, 30 centimetres thick, purchase, hauling, and laying included, will cost, according to the country from which the material is brought, from 2.80 to 3.20 francs, and the same for sidewalks from 0.80 to 1.10 francs. For covering the building department pays per metre from 5.80 to 7 francs.

The paving of streets is made as follows:

(*a*) *Streets of first class.*—The stones are cut out of sound quarry stones, the upper part being made very smooth, and the dimensions are either 15 by 15 centimetres or 12 by 15 centimetres. The height is from 16 to 18 centimetres, and the stones ought to be cut as sharp as possible. Under the pavestones is laid a sand bed 18 centimetres thick. The joints of the stones when laid should not be more than 1 centimetre apart.

(*b*) *Streets of the second and third classes.*—The pavestones are cut from the same material as in the case of streets of the first class, only they are smaller at the top. The height is the same, as well as the bed.

(*c*) *Sidewalks.*—For these, small pavestones are used, and they may be of different colors. Underneath is a sand-bed from 12 to 15 centimetres thick.

The cost of building streets in the city of St. Gallen varies according as to whether the latter are made on level ground or on hillsides.

For instance, taking six of the town streets here, 7 metres wide, macadamized, the cost of a running metre, with sidewalk, gutters, sewers, expropriation of the land, etc, is respectively:

	Francs
Dufour street, with roadway of 5 metres and sidewalk of 2 metres	98.80
Fwingli street, with roadway of 5 metres and sidewalk of 2 metres	85.50
Winkelried street, with roadway of 5 metres and sidewalk of 2 metres	114.00
Vambühl street, with roadway of 4.5 metres and sidewalk of 2.5 metres	111.00
Wildegg street, with roadway of 5 metres and sidewalk of 2 metres	101.50
Treuacker street, with roadway of 5 metres and sidewalk of 2 metres	86.70

A square metre of a paved street costs from 100 to 130 francs. The cost of building the streets and of expropriation of the necessary land are paid by the city, but the adjoining property-holders having houses built along the streets pay upon the total cost sometimes as high as 60 per cent.

The cost of repairing the streets is paid by the city, and amounts, per year per square metre, for macadamized street, to from 0.80 to 1.10 francs; for paved street, to from 0.50 to 10 francs. In the case of paved streets, the cost of repair for the first few years is very small, but when the stones begin to settle or to wear out the cost of repair increases very much.

Experience has shown that it costs much less for the repair of streets paved with small stones as compared with that of those in which large stones are used.

HIGHWAYS.

The country roads of this portion of Switzerland are especially good, and receive constant attention.

The expenses of building and repairing the post or state roads are paid by the national government. Those for the cantonal roads are paid by the canton.

In building a country road, a stone bed from 20 to 25 centimetres thick is made with a covering of gravel from 10 to 15 centimetres thick.

The cost of 1 kilometre of road, purchase of ground included, is, at the minimum, 15,000 francs, and in some localities as high as 100,000 francs.

The use of material depends largely on the location or nature of the country through which the road is to run. For the stone bed, river stones are generally preferred, and for the covering river gravel, but where these can not be had quarry stone and quarry gravel are substituted.

The cost of keeping the road in good order will be, per year, from 300 to 2,500 francs per kilometre, according to the use of the road and the price and quality of the material used for repairing it.

I received last year a letter from A. L. Bancroft, dated San Francisco, June 25, 1890, which, with my reply to the same, will prove interesting in this connection. Our correspondence was as below given:

SAN FRANCISCO, *June* 25, 1890.

DEAR SIR: A movement is inaugurated in one of our counties to name and measure the roads, number the country houses, and place guideboards at the crossings and junctions. As interest is already manifest in other directions, and the movement is likely to spread, I would be thankful to know something of these features in the country where you represent our Government.

Are the country roads named? Are the country houses numbered? If they are numbered, is it done upon any such plan as the "ten-block system"? Are there any celebrated roads, ancient or modern, like Via Appia and Strada della Cornice, of Italy, Watling Street, of England, and the National Road from Washington to Cincinnati in the United States? Will you kindly give the names and descriptions of some of the noted roads in your country?

I will probably make use of the information asked for in a paper for publication.

By complying with this request I will esteem it a particular favor.

Very truly,

A. L. BANCROFT.

Mr. W. HENRY ROBERTSON,
United States Consul, St. Gall, Switzerland.

To Mr. Bancroft's letter I replied as follows:

UNITED STATES CONSULATE,
St. Gall, Switzerland, July 19, 1890.

SIR: As an answer to your letter of the 25th ult., I do not think I can do better than to send you the enclosed copy of a reply from the honorable secretary of the interior, of the canton of St. Gallen, to an inquiry of my own based upon the subject of your communication, above referred to. The honorable secretary has very courteously, promptly, and, I think, very clearly, covered the points to which you referred. I take pleasure in serving you in this matter.

Respectfully,

W. HENRY ROBERTSON,
Consul.

A. L. BANCROFT, Esq.,
132 *Post Street, San Francisco.*

[Inclosure.]

St. Gall, *July* 18, 1890.

To the Honorable W. Henry Robertson,
United States Consul, St. Gall:

I hasten to answer your very esteemed letter of to-day with the following notes:

(1) Are the country roads named?—Answer. They generally bear the names of the principal places they connect. So have we, for instance, the St. Gallen, the Zurich road, the Rorschach road, the Thurgan road, etc.

(2) Are the country houses numbered?—Answer. Yes; but the houses bear only a number indicating the fire insurance, and are of no use in guiding the public. The numbers do not follow each other regularly. A new-built house often gets the next highest running number. But every isolated farm has its own name. The same is the case with every little hamlet. The country people are well acquainted with these names, which very often date hundreds of years ago. If a letter to a countryman must be addressed, it will bear the name of the house or hamlet, never the number of the house.

(3) Are there any celebrated roads like the Via Appia or the National Road from Washington to Cincinnati?—Answer. Yes. The Alpine passes, for instance, the Gotthard road, the Simplon road, the passes of Furca, Oberalp, Albula, Tulier, Splügen, Bernina. In the level country there are no roads with well-known historical names. The country roads are divided by kilometre stones. At every distance of 1 kilometre there is a small stone, and every 5 kilometres is put a large one. At junctions and crossings are high iron or wooden posts, which guide the public and note the distances to the nearest villages and cities. The system of dividing the streets (roads) in imaginary blocks could in our mountainous and hilly country scarcely be adopted. In our cities this system is in use also, but in the country, where very few new houses are built, it would not apply. There in the United States most houses are situated alongside public roads, while in many parts of Switzerland the houses are scattered and sown all over the hills and valleys, and only by narrow footpaths connected with the main roads.

I shall be very glad, Mr. Consul, if I can serve in this matter or in any other way, and I only beg to excuse my English.

With highest esteem, I am, sir, your obedient servant,

W. Künzle,
Secretary.

In thus concluding, I beg to acknowledge the very valuable assistance rendered me by the building department of the canton of St. Gall in the preparation of this report.

W. Henry Robertson,
Consul.

United States Consulate,
St. Gall, March 7, 1891.

UNITED KINGDOM.

ENGLAND.

BRITISH HIGHWAYS.

REPORT BY CONSUL JARRETT, OF BIRMINGHAM.

It is impossible in a report like this to present a survey of the highways of Great Britain, or to give a detailed statement of the method of their construction.

Construction.—Many of them were designed and built by the Romans, and as far as I can discover, nearly all of the existing national roads were designed and constructed before the commencement of the present century.

The systems on which these roads were constructed all involved the preparation of the ground, according to the character of the soil on which the road was built. Pounding the soil to make it firm, driving in piles, or laying on planks or logs crosswise if the soil was boggy, or sometimes placing large rocks, were the usual way of preparing the substratum. This being done, a bed of concrete from 6 to 10 inches thick, or large blocks of stone were carefully and compactly laid to form what was called the subroad, over which was placed the road proper, which was composed of either prepared slabs or blocks of stone, broken stone, or gravel and sand.

About a century ago John Loudan Macadam inaugurated a new system of road making and repairing, to explain which I can do no better here than insert an article clipped from the Southern Planter, of November last, which I find is taken from the evidence of Macadam taken before a Parliamentary committee in 1889:

Macadam's plan of road making differed as much from the old way which he found in operation as a bridge does from a ford. Instead of going deep for a "bottoming," he worked solely on the top. Instead of producing a peaked, roof-like mass of rough, soft rubbish, he got a flat, smooth, and solid surface. In lieu of a road 4½ feet through, he made one of at most 10 inches in thickness; and for rocks and bowlders he substituted stone broken small. His leading principle was that a road ought to be considered as an artificial flooring, so strong and even as to let the heaviest vehicle pass over it without impediment. Then people began to hear with wonder of roads 30 and 40 feet wide rising only 3 inches in the center, and he propounded the extraordinary heresy that a better and more lasting road could be made over the naked surface of a morass than over solid rock. Another of his easy first principles was that the native soil was more resistant when dry than when wet, and that, as in reality it had to carry not alone the traffic but the road also, it ought to be kept in a condition of the greatest resistance; that the best way of keeping it dry was to put over it a covering impervious to rain—the road, in fact; and that the thickness of this covering was to be regulated solely in its relation to its imperviousness, and not at all as to its bearing of weights, to which the native soil was quite equal. Instead of digging a trench, therefore, to do away with the surface of the native soil, he carefully respected it, and raised the road sufficiently above it to let the water run off. Impermeability he obtained by the practical discovery

that stones broken small and shaken and pressed together, as by the traffic on a road, rapidly settled down face to face and angle with angle, and made as close a mass as a wall. Mankind now believe that this last is all that Macadam invented; the rest is forgotten. That important fraction of his discoveries is what has given to us the verb to macadamize ("to pave a road with small broken stones."—Skeat).

Surprise followed surprise. Roads which were mere layers of broken stone, 6, 4, and even as little as 3 inches in thickness, passed through the worst winters without breaking up, while, as the coachman used to say, they "ran true; the wheel ran hard upon them; it ran upon the nail." Commissioners could not believe their eyes when they saw new roads made for much less than it had cost them yearly to repair the old ones. When an old road was given into Macadam's charge, he often made a new one of it for £88 ($440) a mile, while around London the cost of annual repairs had been £470 ($2,350) a mile. For he knew that the roads—such had been the ignorant waste—generally contained materials enough for their use for several years if properly applied. Unless the road was hopeless, he went to work in a practical, cheap way; first cutting off the "gridiron" of ruts in the center "to a level with the bottom of the 'furrows,'" then "picking" the road up to a depth of 4 inches, removing all the chalk, clay, or mud, breaking the largest stones small, and simply putting them back again, and one of his directions to his workmen was that "nothing is to be laid on the clean stone on pretense of binding." But too often the road was so bad, as at Egham, that it had to be removed to its foundations.

For the repairs of his roads, when once made, he always chose wet weather, and "loosened the hardened surface with a pick" before putting on the first broken stone; things familiar enough to us now, but paradoxes then to all the confraternities of the roads. In this way he had the greatest success with the freestone near Bath, and on a road out of Bristol toward Old Down, where everybody had always said a good road never would be made with the material available. This impossible road of 11 miles, which the postmaster-general, as a last resource, was about to indict, he perfected in 2 months, in 1816, for £55 ($275) a mile. Indeed, as to materials, they were to some extent a matter of indifference to him, provided they were stones and stones only.

Even in the breaking of the stones Macadam made a revolution. He saw that able-bodied men standing up with hammers wasted the greater portion of their strength. He made his stonebreakers sit, so that all the force of the blows took direct effect on the stone; and the result was that he found small hammers did the work perfectly well, and thus was able to confine it to old men past hard labor, women and boys, which reduced the cost of the broken stone by one-half. The size to which the stone should be broken he determined in a practical way by the area of contact of an ordinary wheel with a smooth road. This he found to be about an inch lengthwise, and therefore he laid it down that "a stone which exceeds an inch in any of its dimensions is mischievous," that is to say, that the wheel in pressing on one end of it tends to lift the other end out of the road. In practice he found it simplest to fix a weight of 6 ounces, and his surveyors carried about scales to test the largest stones in each heap. He would allow no large stones even for the foundation of his roads, for he found that they constantly worked upward by the pressure and vibration of the traffic. The whole road was small broken stone, even over swampy ground.—St. James Gazette.

From practical experience extending over many years as a member of a highway board having charge of about 25 miles of heavily trafficked road, we are able to say that the application of the principles of road making and repairing laid down in the above article will secure a perfect highway. We worked upon the system invented by Mr. Macadam, using both hand broken and machine-broken stones, and either a heavy horse roller or a steam roller, and made and maintained roads over which upon steep grades one horse could haul a ton in a cart weighing from 1,200 to 1,500 pounds with ease. The state of the roads made in the manner advised, may be judged from

the fact recorded a few days ago in England, that at the recent contest for the championship of the world on a bicycle on the highway, the winner rode in a direct line 336 miles in 24 consecutive hours.—ED.

In constructing a new road, Macadam usually did it in what he termed "three times." He first placed a layer of broken stone 4 inches thick, which was worked until it was set, when another layer of about 4 inches of broken stone was added, which in turn was worked until it was set, when the last layer of broken stone was added.

As to the kind of stone used, the whinstone seems to have been Macadams' favorite, followed by flint, limestone, and pebbles. Burgoyne, in his "Construction of roads," published in 1860, says:

The most important quality in stone for road making is toughness; mere hardness without toughness is of no use, as such stone becomes rapidly reduced to powder by the action of the wheels. Those stones which have been found to answer this purpose best are the whinstones, basalts, granites, and beach pebbles. The softer descriptions of stone, such as the sandstones, are not fitted for this purpose, being far too weak to resist the crushing action of the wheels. The harder and more compact limestones may be employed; but generally speaking, the limestones are to be avoided in consequence of their great affinity for water, which causes them, in frosty weather, which has been preceded by wet, to split up into a pulverulent state, and destroys the solidity of the road.

It is extremely difficult to arrive at the first cost of construction or that of repairing and keeping in good order the roads of this country, as I fail to discover any reliable data on the subject. The labor employed at this class of work is, and has been of the cheapest kind. Criminals have also been largely employed for this purpose. At stone breaking, women and children are still employed. During times of depression, workmen out of work are often employed for as low as 36 cents and 61 cents per day, at stone breaking and road repairing. The men employed at this work regularly are paid from 61 cents to 73 cents per day.

An approximate estimate of the cost of keeping in repair country roads would be from 3 cents to 5 cents per superficial yard. The probable cost of construction of new roads, irrespective of the value of the land, would be from 49 cents to 73 cents per superficial yard.

Tollgates.—The roads in England were until recently under the control and management of certain bodies called turnpike trusts or trustees, who were usually appointed by acts of Parliament applying to separate and distinct districts. Under these acts the turnpike trustees were authorized to collect from the drivers of all vehicles or from persons traveling on horseback, small sums which were called tolls. These tolls were collected in the highroads at various points at a tollhouse, being a small two-roomed cottage erected close up to the road, where a tollgate was fixed. This gate was a five-barred gate which was kept locked, and opened for each passenger on payment of the toll.

These tollhouses would in some districts be from 4 to 5 miles apart, and in others would be within much shorter distances, as the traveler

happened to get on the roads governed by different trustees. These tolls were for a two-wheeled vehicle generally about 6 cents each, and for a horseman 2 cents or 3 cents. Each person paying the toll received a small ticket marking the toll, and the toll paid in some instances freeing the passenger for a gate further on the road. In some districts tolls were very much higher than in others.

A friend tells me that he remembers once driving through Wales in a two-wheeled vehicle, perhaps about 25 years ago, when he was surprised to find all the roads in splendid condition, but the tollgates were very numerous, being met with in every mile or so, and rates ranging from 14 cents to 30 cents each toll.

These tollhouses had their bright side. They were usually pleasant breaks on a long journey, and many has been the agreeable chat with the old toll-keeper, who could usually spin a good yarn, and the fact of the tollhouse being there was often a protection to travelers on a long journey.

In Dick Turpin's (a famous highwayman) historical ride from London to York, about 200 miles, he may be remembered as having cleared a good many of the tollgates without stopping to pay the toll. As to these tolls there were certain persons who were exempt from payment of them, viz: Horses or carriages attending or going to attend queen or sovereign; horses employed in husbandry; vehicles conveying materials for mending the road; persons going to or returning from church or a funeral within the parish; ministers attending service; officers with prisoners. Also no toll to be taken for simply crossing the road or going 100 yards upon it. Also cattle, etc., going or returning from pasture.

These turnpike trusts were done away with by act of Parliament passed in 1878, known as the highways amendment act (41 and 42 Vict., c. 77) after which in the course of a very short space of time the old tollhouses gradually disappeared.

Under the act of 1878 and subsequent acts of Parliament it is provided:

First, the duty, maintenance, etc., of the highways is cast upon the ratepayers of the parish and managed by their highway surveyor.

Second, parishes are united into districts for the common object, under the supervision of the highway boards.

Third, municipal boroughs and towns have powers conferred upon them to perform the duties of highway surveyors within their boundaries.

Lastly, the central authority, the local government board, London, is intrusted with a general superintendence of the several systems for the benefit of the nation at large.

In order to raise the necessary funds for the maintenance of the highways the rateable property value in each parish is ascertained, according to the valuation list in such parish, or if no valuation list be in force,

by the justices of the peace, subject to appeal at the quarter sessions.

The surveyor is empowered to inspect any of the rates towards the relief of the poor, or the books of the assessment, and is allowed to make copies and extracts. The surveyor is to levy a rate upon all property rated, to the relief of the poor, and he has the same powers as the overseers of the poor for the recovery of the rate, and if it is not paid he can issue a summons for its recovery before the magistrates of the district.

No highway rate by any parish at any one time is to exceed 10*d.* (20 cents) in the £1 ($4.86), and the highway rates required to be paid in any one year are not to exceed 2*s.* 6*d* (61 cents) in the £1 ($4.86), except with the consent of four-fifths of the ratepayers of the district, procured at a meeting specially called. Property is assessed in England according to the rental value, and not on its full value, as in the United States.

RIGHTS OF BICYCLISTS.

(Suggested by the by-laws of the highways act, 1878, 41 and 42, Vict. C. 77, for the use of county commissioners of highways.)

In these by-laws the expression "bicyclist" means a person riding or otherwise using a bicycle on any highway.

A bicyclist shall not ride his bicycle upon any footway, pavement, or causeway set apart for the use of foot passengers.

Every bicylist who rides a bicycle during the time between one hour after sunset and one hour before sunrise shall have attached to his bicycle a lamp, so placed as to afford adequate means of indicating the approach of such bicycle.

Every bicyclist who overtakes any wagon, cart, or other carriage, or any horse, or any foot passenger proceeding along the carriage way, shall, when within a reasonable distance before passing such, by sounding a horn, bell, or whistle, give audible warning of the approach of his bicycle.

Every bicyclist who overtakes and passes any wagon, cart, or other carriage, or any horse, shall keep his bicycle to the right or off-side of the road.

In every case where a bicyclist meets or overtakes any horse which may become restive, such bicyclist shall take every reasonable precaution, to the best of his judgment, by dismounting or otherwise, so as to avoid danger.

Any person who breaks any of the foregoing by-laws shall be liable for any one offense to a fine of not exceeding two pounds ($9.73).

VALUE OF HIGHWAYS.

I have been unable to obtain any data showing "the effect of improved public highways upon land values and other economic conditions," for Great Britain. It is however safe to say that land values are improved, and that every branch of agriculture, commercial, and manufacturing industries is materially benefited through the operations of

good public roads in this country. There can be no question but that the great industries owe much of their development and prosperity to the excellent public roads. Horse power is vastly utilized by them, and the general comfort of the individual is increased. In short the public and private advantages resulting from the good roads are incalculable. Much may be said in favor of the old mode of maintaining the roads by means of the tolls, as the expense fell upon the persons using the roads, but it will be clearly seen that as this country (England) is small and thickly populated with large towns in close proximity to each other that the system now in force of having the rate payers of each parish bear this expense, is by far the most expedient and preferable. This system, however, in my opinion would have to be very much modified in its application to the construction and maintenance of public roads in the United States.

JOHN JARRETT,
Consul.

UNITED STATES CONSULATE,
Birmingham, Feb. 13, 1891.

ENGLISH STREETS AND HIGHWAYS.

REPORT BY CONSUL WIGFALL OF LEEDS.

MISCELLANEOUS STATISTICS.

An abstract of returns of turnpike trusts round about London for the year 1818 shows a length of road 210 miles 489 yards, under twelve distinct organizations, under acts of Parliament of various dates from the seventh to the fifty-eighth years of the reign of George III. The amount of tolls during the year named was £97,482.18.9 ($474,400.72); the amount of expenses, £98,856.0.6 ($481,082.85); and the outstanding debt, £62,658.7.0 ($304,926.86); or, per mile, tolls, £464.4.0 ($2,259.03); expenses, £470.14.0 ($2,290.66); debt, £298.7.0 ($1,451.92).

Such a statement is perhaps its own sufficient comment.

From a condition like that presented by these figures it is not far or difficult to conclude a course of administration the reverse of satisfactory. And that indeed was the fact. Too minute a subdivision of interest with its accompanying irresponsibility of control had wrought something closely approaching to ruin in the English system of public roads.

The elder McAdam, in his remarks (edition of 1822), refers to the amendment of a large proportion of the turnpike roads and some improvement of the parish roads as having occurred since the publication of the early editions of his essay. The fact that the reformation had not been more extensive and successful was, in his opinion, attributable

to the error still persisted in by trustees of continuing the services of persons as road surveyors who, he says, are not only altogether ignorant of the business they profess, but full of prejudices in favor of their own erroneous practice.

Six years' experience the author says has served to confirm his belief that the supervision of commissioners over surveyers is altogether ineffectual; whether for direction in their active duties or for protecting the funds of trusts (as the turnpike organizations were designated) from waste and peculation. The commissioners were unpaid and irresponsible, and the work done under their nominal authority and direction was correspondingly defective. England alone was parceled out "into 955 little trusts," which by dint of their numerous smallness had sunk into very low credit. The debt was at that writing seven millions sterling and promising to increase.

The modes of making and repairing roads were various in the different portions of the kingdom, being to a certain degree affected by the varying supply of materials. Gravel in the London neighborhood; flint in Essex and Sussex; in the west, limestone; in the north and in Scotland, whinstone, and in Shropshire and Staffordshire, pebbles mixed with sand. Excellent roads, Mr. McAdam states, may be made of any of these materials.

The London gravel mixed with clay and lacking angular points of contact whereby broken stone unites and forms a solid body, was found the least desirable. With proper treatment, however, even this would make good roads. Flint is called an excellent medium if due attention is given to the size. Limestone makes a smooth and solid road, consolidating sooner than any other material, but is not the most lasting. Whinstone is the most durable of all, and makes roads comparatively good and cheap. The pebbles of Shropshire are hard and do well for roads. The Scottish roads, though made of the best materials, were termed the most loose, rough, and expensive roads in the United Kingdom.

The form of road is objected to by the author, particularly the roads about London, high in the center of the way and making a dangerous slope except just in the middle of the road. Loose gravel was deposited in the center and left to work its way outward.

A road well made, it is said, will be easily repaired. Hence the necessity of intelligent supervision in the outset. Mr. McAdam continues:

> Will it be deemed presumptuous to propose that some regulations may be adopted for encouraging and promoting a better system of making roads, by eliciting the excretion and by creating a set of officers of skill and reputation to superintend this most essential branch of domestic economy?

The duties of an active executive officer are reckoned to include direction of repairs and alterations, control of contracts, and general superintendance of employés, and supervision of the accounts. A stint

of, say, 150 miles, it was thought, would give such an officer full occupation. He adds:

Skill and executive labor must be adequately paid for, if expected to be constantly and usefully exerted; and if so exerted the price is no consideration when compared with the advantage to the public.

He is explicit in condemnation of statute labor for the maintenance of roads. He says it was decreed when no better means could be devised, at a time when a circulating medium was deficient and labor in many parts was hard to get for money. "Personal labor for a public service can never be made profitable or fairly productive." A commutation of statute labor for a moderate assessment in money was accordingly commended, and had then been effected in Scotland in most if not all of the turnpike acts by the local powers.

The insufficiency or improvident expenditure of the funds provided for by Parliament was proven by the numerous applications for extension of powers and increase of tolls. In the session of 1815 thirty-four such petitions, and in 1816 thirty-two, were presented and passed as a matter of course.

Mr. Macadam goes on to say:

The defective state of the roads, independent of the unnecessary expense, is oppressive on aggriculture, commerce, and manufactures by the increase of the price of transport by waste of the labor of cattle and wear of carriages, as well as by causing much delay of time.

The author says he has abstained from any notice of the parish roads, although their condition and the state of their funds are more deplorable than that of the turnpike roads. He adds that the legislation on their behalf is so inadequate that they may be considered as being placed almost out of the protection of the law. They should be aggregated with the turnpikes and placed altogether under proper scientific and expert management.

An interesting extract from a Parliamentary report in 1811 contains the following statement:

The many important advantages to be derived from amending the highways and turnpike roads of the Kingdom need hardly be dwelt upon. Every individual in it would thereby find his comforts materially increased and his interest greatly promoted. By the improvement of our roads every branch of our agricultaral, commercial, and manufacturing industry would be materially benefited.

Mr. Thomas Telford, before a committee of Parliament in 1819, said that the roads in England and Wales were in general very defective, both as to their directions and inclinations, being often carried over hills which might be avoided by passing along the adjacent valleys; that the inclinations were inconveniently steep and long continued, and specifies some previously existing conditions of grade as one in six, seven, eight, nine, and ten, with a width of 12 feet, without protection on the lower side, and the roadway itself improperly constructed. These had been corrected, and at the time the sharpest grade on the

road referred to was 1 in 17 for about 200 yards; another was 1 in 22 for a considerable distance, unavoidable from the lay of the ground; but the general grades on this road after the improvement were less than 1 in 30, with 32 feet breadth of roadway on level ground, 28 where side cutting did not exceed 3 feet, and along steep and precipitous parts 22 feet, all within the fences.

Between Shrewsbury and London this road still made its way over many hills. Another instance cited was between Shrewsbury and Worcester, which consisted of nearly a succession of very high and inconveniently steep hills, although very easy inclinations might be obtained by passing along the side of the river Severn.

These roads were cited by Mr. Telford as typical of many other roads in the Kingdom, not having been selected as more particularly defective than others. He adds that the shape or cross-section and drainage are quite as defective as the general direction and inclinations. No attention to constructing the foundations; materials seldom sufficiently selected and arranged; promiscously scattered on the road, impeding the travel and lending aid to destruction; the roadway hollow in the middle; the sides incumbered with mud in banks 6 and 8 feet high. Such are the attributes of the British highways at the time. Since then but fifty years have passed, and mighty has been the change. The description which we have just been traversing has many features which might suit an essay on the facilities existing at the present moment in a large number of the United States. The heedless manner in which so frequently the routes are selected; the utter disregard of grade; the boundary of a cornfield given preference for location of the line of road to the plainest topographical necessity; the wretched pretense of drainage which only works the ruin of the roadbed. These, and a multitude of similar reflections, may find analogy in the spirited complaint put forth fifty years ago in England.

The most important element in the problem seems to be the one which in the discussions of that and later periods has been so urgently insisted on in England, viz, the employment of competent expert capacity to personally and immediately supervise the designing, locating, constructing, and maintaining of the highways of the various country-sides. In even the remotest districts, destitute of facilities for exterior supply of road-making material, and where the natural resources of the country do not furnish it, there is still, and here even more perhaps than in more favored regions, the necesssity for skill and trained capacity in road building. A well-planned, scientifically executed line of highway, judiciously graded, sufficiently drained, properly protected from rain and flood, and systematically supervised and kept in repair, might well offer facilities, even with a roadbed of the native soil unmetaled, superior for traffic to the heaviest accretion of stone, unskillfully disposed and left by neglect to decay. It is prominently apparent in any fair consideration of the subject that competent special

ability in the selection of the route, in the management of levels, in the application of material, and in the unintermitting care of the roadway after it is built, is the essential and indispensable requirement for the proper development of our road system. No natural advantages can take the place of intelligent use of the means actually in hand.

The same irresponsibility, the same lack of individual personal interest and trained capacity on the part of those charged with the management of the English road systems in former times is now working its evil effects in our own States. Organization, liberal and coincidently judicious outlay of money, and expert supervision are vital needs in this connection.

Mr. Thomas Codrington, general superintendent of county roads for South Wales, a recognized authority, in his "Maintenance of Macadamized Roads," edition 1879, begins his preface by a statement that his subject is one upon which the published information in England is remarkably scanty. He speaks of the engineers of the Ponts et Chaussées in France as having been foremost in inquiries of this sort, and adds that the results of their labors are fortunately for the most part as applicable in England as in their own country. The lack of knowledge in England as to systematic road maintenance he considers will become more apparent in consequence of the then recent legislation by which half the cost of repairing the main roads had been made to fall upon the county rate, with the inferable consequence of supervision by the county authorities.

Application of new materials, prevention of avoidable wear by keeping the surface and the body of the road in good condition, removal of detritus as it forms, care of the surface and attention to drainage, are the points suggested as important. Four horses doing the work of five or three the work of four are results to be attained by proper management of the roadways, accompanied by saving of wear and tear of harness and vehicles. But actual economy in cost of maintenance generally he thinks follows as well. A good road is cheaper as well as better than a bad one. He speaks of upwards of £4,000,000 ($19,466,000) being spent annually on the roads of England and Wales, this expenditure being nearly all on macadamized ways. It is also exclusive of the London district, where macadamized roads are debited with £280,000 ($1,362,620) annual outlay. A large saving is reckoned possible on this, given more system and skill in administration; while the indirect economy in cost of drought and wear and tear is reckoned would probably far exceed the direct, considerable as the latter might be; so essential does this judicious writer deem the employment of expert superintendence. And the same text which Telford and Macadam expounded sixty years before has kept its vitality to this later day.

Telford and Macadam, while coincident in their aims, seem somewhat divergent as to method. The prominent point of difference in their theories would seem to have consisted in their requirements as to the

shape and size of the metal constituents used in the roadbed. The one held favorably the use of a bottoming of more or less symmetrically shaped stones of appreciable size set in careful order and forming a substantial foundation wherever was to be arranged the mass of smaller stones to make the surface of the way. The other assumed an antipodal position, and held that no foundation was so good as the native soil, handled, and shaped, and drained, where possible, but preserved from any sort of contact with stones of individual importance, size, and weight. These he deemed to be absolutely mischievous to cause injury to the stability of the working stratum of the road. This plan was uniformity of size (6 ounces in weight was his standard), and the stone distributed without mixture of earth, clay, chalk, or any matter which will imbibe water and be affected by frost; nothing to be applied for "binding." Broken stone, he says, will combine by its own angles into a smooth surface beyond the attack either of weather or wheels. Placing stone under the road to make it artificially strong enough to bear heavy carriages, though the subsoil is wet, and to try thus to avoid harm of water penetrating the soil, he says, has led to most of the defects of British roads. Strata of stone of various sizes will cause constant working up of the largest stones—uniform size from the bottom he holds to be the only remedy. He goes so far as to say that a road over a morass lasts much longer than when made over rock, citing in this connection the road between Bristol and Bridgewater, as showing a comparison of five to seven in favor of the wearing on the morass where the road was laid upon the naked soil against a part of the same road made over rocky ground. The thickness of the road he deems immaterial so far as regards its strength for carrying weight. The subsoil, which is kept dry by the road acting as a roof, bears the load as well as the road. He insists upon dryness to facilitate this effect. The morass of his illustration would seem, therefore, to have been a sort of dry morass.

Mr. Codrington thinks that this difference between the two engineers has been more dwelt on than the similarity of their systems on many other points in which they varied so widely from the practice of their predecessors. Both, for example, insisted on the necessity for the thorough drainage of the seat of the road (previously quite neglected) and both made use of materials broken to gauge to form a solid hard surface of a uniform cross-section and of curvature just sufficient to throw the rain-water freely to the sides. Telford's description is quoted:

> This foundation is a regular close pavement of stones carefully set by hand, and varying in height from 8 to 6 inches, to suit the curvature of the road. These stones are all set on edge, but with the flat one lowest, so that each shall rest perfectly firm. The interstices are then pinned with small stones, and care is taken that no stone shall be broader than 4 or 5 inches, as the upper stratum does not bind upon them so well when they much exceed that breadth. The pavement thus constructed is quite firm and immovable, and forms a complete separation between the top stratum of broken stones and the retentive soil below.

The French engineer, Tresaguet's, mode described by himself in 1764, and adopted generally in France in 1775, is cited for comparison, and shows great similarity.

Mr. Codrington, in this connection, distinguishes between "a firm and regular bottoming" to separate the road metaling from the subsoil and "a pavement." In order to secure a dry bottom, and to avoid suffering the workable materials coming into contact with clay, Telford was willing to get the effect by almost any means available; and suggested gravel, sand, vegetable soil, or chalk as alternatives to bottoming stones; a requisite, whatever the medium, was that "this bottoming should be made perfectly firm and regular, so as to receive the top workable metal of equal thickness." Thus it is said, although he always advised a paved bottom when it could be laid, many pieces of road were made under Telford's direction without the paved bottom, with which his name has been associated.

Mr. Codrington is of opinion that where the bottom is soft and wet and the subsoil can not be laid dry by drainage, a bottoming of some sort is very desirable, and that stone will be often found the most economical as well as the most convenient medium if considerable strength is required. Three or 4 inches of broken stone laid on 6 inches of pitching consolidates, he says, much more quickly under ordinary traffic than the 9 or 10 inches of broken stone alone. Stone for bottoming may be of a quality unfit for metaling or building. Macadam's objection that large stones would work up, Mr. Codrington limits to those thrown down anyhow on to an undrained subsoil, as per the older roadmakers, but denies that it applies to a carfully pitched foundation, a bottoming of stones on edge. The plea that the metaling is "ground to powder" between the wheel and the underlying pavement has been made, but sufficient thickness of metal is thought to obviate this danger. On a soft subsoil, where a pitched bottoming is most useful, experience is said to prove that the broken stone may be reduced by wear to 1½ or 2 inches in thickness without such action.

Mr. Codrington attributes a good deal of exaggeration to many of Macadam's statements. He deems it quite contrary to other experience that materials should last longer on a soft bottom, and says the morass road may have worn well in spite of its foundation and not because of it; and, he adds, that the saving in wear of materials on what he terms "a flexible road" could only have been obtained at the expense of increased draft of vehicle. He also takes exception to the theory of satisfaction from imperviousness to water alone, without reference to weight-carrying power advanced by Macadam. He goes so far as to say that while a water-tight covering, as in limestone roads, is desirable, roads of silicious material, though always more or less permeable, may be also very good. Modern practice, he says, varies from Macadam's precepts in other points; but the principle of broken stone laid directly on the natural soil has guided the construction of, by far,

the largest proportion of the roads of the present day, both in England and abroad. He gives Macadam the credit of first calling attention to the proper preparation of materials and the possibility of a road surface nearly impenetrable to water, though flat enough for vehicles over the whole area. To him also, he concedes, is largely due the establishment of a regular system of road maintenance under properly qualified surveyors. This alone would seem to entitle Macadam's name to high consideration in the country which has so benefited by his service.

ROAD CONSTRUCTION.

Regarding the construction of roads Mr. Codrington summarizes the subject under the following heads:

1. Drainage.
2. Cross section.
3. Road with a pitched foundation.
4. Concrete foundations.
5. Broken-stone road.
6. Breadth.
7. Water tables or side channels.
8. Outlets.
9. Foot path.
10. Fences.
11. Stone depots.
12. Rolling.
13. Use of a binding material.
14. Cost of macadamized roads.
15. Reforming an old road, and
16. Lifting a road.

(1) *Drainage.*—This is essential whether a paved bottom is laid or not. Ditches on each side of the road 2 or 3 feet deep are usually sufficient. They may be on either the field or the road side of the fence; better the latter if other things agree. They are easier of access and being nearer give more complete drainage. Where the road is below the level of the land the drains are often covered in. They should be under the side channel, 1 foot or so deep below the formation surface, and filled in with rubblestone to join with the road materials. Surface water should be otherwise provided for by open drains. If side ditches and drains are not enough miter drains must be added. These are drains meeting in a V in the center of the road and running to the side drains in the direction in which the road falls. One in 100 is sufficient inclination. They are cut in the formation surface 6 inches deep and 12 inches wide, filled in with broken stone. Drain pipes or box drains with side walls of dry stone and flat bottom and cover stone may be used. The latter have the advantage that they can be opened and cleaned. Care must be taken to tap and lead away springs rising under the road. Both the general highway and the turnpike acts give power to make drains through lands adjoining a road, with satisfaction for the damage. Draining is economy. A wet road is always troublesome. Ex-

pense in drainage is well expended. Culverts are required for surface water passing the road. Slight fall in these is best.

(2) *Cross section.*—Rain must be shed. A moderate inclination from the center to the sides will be enough, and best. Too great convexity throws traffic to the middle of the road. A flatter section distributes it. Fair surface makes water flow freely better than steepness. New roads more convex since the middle consolidates more by traffic, which is to be allowed for. Telford's section was a flat elliptical curve, differing slightly from an arc of a circle, by being more convex in the middle than at the sides. Walker recommended two straight lines following about 1 in 24 toward the sides and joined in the middle of the section by a curve. A common form is a elliptical curve, flatter in the middle than at the sides, which is apt to be too flat, though it makes good side channels, Either a flat ellipse like Pelford's or an arc of a circle is perhaps on the whole preferable. But regularity and evenness are more important than these slight differences. Six inches' fall from center to sides is enough for a 30-foot road and the fall should never go beyond 9 inches; for 18 or 20 feet breadth 3 or 4 inches is called enough. On a level road a rather rounder section is called for than on one with moderate gradients. On hills the side fall should lead the water off and prevent its following the surface along the lengths of the road. Water carried off a road by going down the wheel tracks is drainage misapplied. The side channels may be shaped to suit the bulk of water coming on them; but their tendency in being cleaned is to get deeper unless they are pitched.

The convexity of surface may be made either in the foundation or the road coating. Telford's practice was a level roadbed and convexity obtained by thinning both the pitching and metaling at the sides. On some parts of the Holyhead road the paved bottom on a level bed diminished from 7 inches at the center to 3 inches at the sides of a 30-foot road, then giving 4 inches fall in 15 feet on which broken stone was laid 6 inches in thickness for a breadth of 18 feet in the middle and thinning out from 6 inches to 4 inches in the 6 feet of width remaining on each side with 1½ inches of gravel over all, so that the finished road had a total convexity of 6 inches. On other parts of this road the paved bottom was laid over only 18 feet of the middle of a 30-foot road, diminishing from 7 to 5 inches in thickness with a layer of broken metal 6 inches thick over. On the portions without paved bottom the convexity was given partly in the gravel bottoming, 7 inches in the center and 2 inches at the sides of a 30-foot road, and partly in the top metaling of broken flint and large gravel which varied from 8 inches in depth in the middle to 4 inches at the sides with 1½ inch of binding gravel over all; thus giving 9 inches of convexity in the 30-foot width. Making the sides weaker than the middle is called, however, of doubtful utility in roads of ordinary dimensions. The sides are subject to heavy strains and need to be strong. An ordinary new road should have the roadbed shaped

to obtain the desired surface and at the same time to admit a uniform thickness of metaling, or only slightly thicker in the middle to allow for consolidation. This is thought advantageous also for dryness. The original surface should be undisturbed as far as possible, hollows being filled up from the adjacent ground rather than the elevations cut down. This particularly as to a clay subsoil. After getting into shape roller should be applied. Surface for metaling should be set out and shouldering to confine road materials be formed either in the solid or by sods backed up with earth. Outlets through the shouldering should be left for water from the road.

(3) *Road with a pitched foundation.*—Stones must be set by hand in close order broadest edge down and across the direction of the road. Laying flat gives a tendency to unsteadiness and the metaling does not bind so well. Upper edges should not exceed 4 inches in breadth. Inequalities should be hammered off and small stones packed in the interstices. Carts should keep off till the pavement has a coating of broken stone. This should be 3 or 4 inches deep for the first coat, and raked in the ruts while consolidating under traffic; and the remainder should be put on when the first is nearly set. With ordinary traffic 4 inches of broken stone over a pitched foundation should consolidate in about 3 months. Four inches of pitching and 4 of metaling are inside limits for thickness; 7 inches for pitching, and 6 for metaling mark the other extreme. In a level street a pitched foundation must fall near the gullies, or else the metaling will have to be too thin at the side.

(4) *Concrete foundations.*—Roman concrete 6 inches thick. Broken stone thereon 6 inches more. Upper surface of concrete indented to hold stone and drain off water. Annual wear of this reported ½ inch. Common lime concrete also used, 6 inches thick; two layers of stone, 3 and 3 inches; the first laid before the concrete had set, which took in this stone, the upper layer after the first was partly consolidated by the traffic. Lias lime concrete also employed on Victoria and Chelsea embankments, 12 inches thick on slightly convex formation of surface stretching under the curbs of the footways. Six inches of granite in two courses, each rolled, was added after the concrete had thoroughly set; on a clay subsoil small gravel or sand 2 or 3 inches deep before the metaling is applied will cut off the clay. Chalk has also been used, but is called dangerous through effects of frost.

(5) *Broken-stone road.*—If a road is entirely of broken stone a layer 3 to 6 inches should be laid first and in dry weather. After consolidation begins add more, and so on till completed. Ruts require raking as soon as they appear. The layers after the first want wet weather. Too thick at first makes waste; but heavy traffic requires, especially with a soft bottom, a good thickness in the first layer. A new road needs rarely less than 6 inches for first layer. This on a good well drained road will serve a considerable country traffic. Macadam considered 10 inches of well consolidated material enough for any traffic on any sub-

stratum. Experience has proved this true in well drained and well kept roads even in London. Eight or 9 inches is usually enough; and gradually to apply by successive coats is better than putting on all at once.

(6) *Breadth.*—This should be enough to accommodate the traffic: 12 to 15 feet in country; 30 to 50 feet near towns. Fifteen feet permits two vehicles to pass. A few feet extra gives much relief. Hills render extra breadth desirable. Uniform breadth and well defined side channels are "neat and useful."

(7) *Water tables or side channels.*—Where the road abuts against banks or walls the slope near the meeting makes the water tablè or side channel. Usually, however, space exists on either side the metaled surface, and a sod or curbing should define the road and form the water table. Sods about 12 inches wide and 4 or 5 thick, 2 high, backed with earth, make a bank for a footpath or place for road scrapings, and is reckoned to cost 1*d.* to 1½*d.* (2 to 3 cents) per linear yard. Flat stones may be used for the water table, or asphalt made of gas tar, gravel, and road scrapings or other methods as to local circumstances.

Limestone curbs 1 foot deep and 4 inches wide are quoted 2*s.* 6*d.* (61 cents) to 3*s.* 6*d.* (85 cents) per linear yard. Granite curbs 12 inches wide and 9 inches deep, suitable for towns, cost 6*s.* 6*d.* ($1.58) to 7*s.* ($1.70) per linear yard.

In villages or where the road is bordered with houses a shallow gutter is more suitable; a slope to the road meeting the metaling in the line of the water table, which latter may be pitched or channeled. At junctions the channels require special attention, and cross drains may be used.

(8) *Outlets.*—Numerous outlets for water are necessary. It should not be allowed to stand. On hills outlets are specially required.

(9) *Footpath.*—If made it should be 9 or 10 inches above the water table and have a slope towards the road of about 1 in 30.

(10) *Fences.*—A post and rail fence is best because it does not shade the road. A bank and hedge are cheaper.

(11) *Stone depots.*—These are recesses to contain material for repairs. They should be near enough together to allow the roadmen to wheel out the materials to any part of the road.

(12) *Rolling.*—A new road should always be finished by rolling. The metaling is thus consolidated without the grinding and crushing by wheels of vehicles. Horse rollers are 3 to 4½ feet or more in diameter and 4 to 5 feet long, or of two or more cylinders side, by side, weight (not loaded) 2 to 3 tons. By loading a box or filling cylinder with water, weight may be increased for subsequent heavier work as the road consolidates. Pressure is desired to the extent of a ton to a ton and a half per foot width of roller, a 4-foot roller, 6 tons, requiring 6 horses. Horses feet tear the road if materials are loose and draft heavy. For superior work and economy steam rollers are preferred. A steam roller

weighing 15 tons, 7 feet wide, 2 tons per foot, compresses far more rapidly than a horse roller. It can do thoroughly 1,000 to 2,000 square yards of newly laid stones per day; 4 to 5 inches of stone may be rolled at once; thicker is better twice separately, in different coats. Any large stones or surface should be broken. Horse rollers go over several times unloaded, and hollows are filled with small materials. When the road begins to set the roller is partly loaded, and finally fully and until the stones are quite steady in place. A steam roller has all the weight at first. Artificial watering is necessary unless the weather is wet; 4 or 5 inches generally consolidate better than either thicker or thinner. Commence at the sides, and work to the middle. When the stones are thoroughly wedged together, but not before, binding must be added. This may be fine gravel, road scrapings, or sand. Chalky or clayey binding should be avoided. Limestone detritus is best with silicious materials and sand may be used with limestone road. Binding should be spread dry with a shovel, and uniformly, and worked in gradually with the help of watering and sweeping in addition to the rolling. As little as possible for effecting the purpose is best to use. The object is to consolidate the road, and the coalescing of the material of which its bulk is composed is to be sought for. The binding is only by way of supplement, and too much hurts the durability of the road. One quarter the bulk of the stones is sometimes used in France and one-sixth is the official proportion at Mandover.

(13) *Use of a binding material.*—Macadam and others have discountenanced the use of binding, but Mr. Codington thinks the proper use of it on a new road is founded on reason. It should be applied after the stone is laid, not mixed with it.

(14) *Cost of macadamized roads.*—This varies greatly. With materials close at hand a good road may be formed and coated for 1*s.* or 1*s.* 3*d.* (24 to 30 cents) per square yard, and a London street constructed in the best manner, with 9 inches of Guernsey granite, may cost as much as 6*s.* or 7*s.* ($1.44 or $1.68) per square yard.

The following particulars of the construction of roads near London are given from Sir James Macadam; time apparently about 1850:

For a road of the first-class, sufficient for a street with the heaviest traffic, 4 inches of gravel, riddled and broken so that no piece exceeded 3 ounces, was laid on a well-drained and prepared surface having a fall of an inch in a yard from the center towards the sides. When partly consolidated by traffic or by a roller, 2 or 3 inches more was laid, and over this, when sufficiently consolidated, 3 inches of granite or other hard stone. The furrows were kept raked, and the cross section maintained in true form until the whole was consolidated, but no binding was used. The second-class roads required 4 inches of gravel and 3 inches of hard stone or granite; and the third-class 3 inches of gravel and 2 inches of granite or hard stone. Taking the gravel at 5*s.* ($1.20) per cubic yard, the drainage and preparation of the surface and spreading and raking, each at 2*d.* (4 cents) per square yard, a first-class road was estimated to cost 2*s.* 6*d.* (60 cents) per square yard. Granite is now (1879) 16*s.* to 18*s.* ($3.84 to $4.32) a cubic yard, and other prices are higher. In London streets, instead of the gravel, hard core, clinker, brick, or stone rubbish is now often used for the bottom 9 or 12

inches, over which 3 inches of Thames ballast is laid, and then the granite or hard stone, which is often thicker than 3 inches. The bottoming, the ballast, and the top metalling are generally now rolled separately, and the cost may be, as above stated, 6*s.* or 7*s.* ($1.44 or $1.68) per square yard.

(15) *Reforming an old road.*—The general objects should be the same as in making a new one. Drainage of foundation and surface, good and regular cross section, and sufficient strength, are the leading ideas.

Present condition is tested by sounding or digging small holes in the surface. Fresh material is to be added to a thin road, giving proper form, digging out and putting in, breaking unduly large stones, and side channels regulated. Mud and detritus must be sufficiently removed, and hollows filled up. Gradual improvement without unnecessary pulling to pieces should be the rule.

(16) *Lifting a road.*—A road sometimes contains enough or nearly enough material for its own reconstruction. The whole body is loosened with the pick. All stones over 6 ounces in weight, or which will not pass through a 2½-inch ring, are raked aside and broken to that gauge. After removing the large stones what are left are put in shape and the large ones broken up and spread on the surface. The surface may properly be lifted to 4 inches depth rather than altogether, as the bottom may be poor. Quarry rubbish or other dry material may be spread on the foundation before the stone taken out is replaced and fresh materials may be added. Two or three yards at one time is enough to lift. Macadam estimated lifting a rough road 4 inches, breaking stones, reforming surface, and cleaning water courses to cost from 1*d.* to 2*d.* (2 to 4 cents) per square yard lifted. A condition of road where there is plenty of stone, imperfectly broken, badly arranged and mixed with the soil, is one where lifting may be desirable. In many cases it would be unadvisable.

STREETS OF LEEDS.

The new streets in the town of Leeds are understood to be normally 12 yards wide. This is subject to numerous exceptions in the older parts of the borough, where width and directions are very irregular. The cost of paving is borne by the owners of property binding on the area paved. The average cost price of paving per lineal yard of boundary line, by which the assessment is laid, is reckoned to be something like about 25*s.* 4*d.* (see annexed schedules) ($6.08). The liability of the owner extends over half the area of his front, which is a street of normal width as above of 12 yards, would cover 6 yards to the front, making the lineal yard represent 6 superficial yards, and the corresponding cost per superficial yard on that average 4*s.* 2*d.* ($1.01).

As preliminary to making a new street, notice is posted of intended paving. This stands three weeks. This is understood to be warning

to the owner to begin and pave the street at his own cost and charges. The owner, however, sedulously omits compliance, and allows time to lapse. When five months have passed the corporation comes upon the field, and, having let a contract, proceeds to have the work completed; and having done so, and the job having undergone the necessary proof of fulfillment of the terms of the contract, the owner is amerced in the amount of the cost, each one proportionally to the length of his front boundary line. Details of contract are annexed in printed form, as also two *pro forma* tenders, giving approximate prices for the various items thereon set forth. One of these is for ordinary paving in accordance with the printed specification therefor above referred to, and the other is for macadamizing with specification pertaining thereto, also attached in writing.

There is another statement annexed to which special attention is invited, the estimate of 25l ($6.08), per lineal yard of a 12-yard street is a very general sort of average, and more accuracy can perhaps be obtained by collocation of the figures given on the *pro forma* tenders and Mr. Prince's statement, which is here referred to.

My hearty thanks are due to Mr. Prince, who is the highways surveyor of the borough of Leeds, for his interesting information.

LEEDS IMPROVEMENT ACTS.

Tender for paving, flagging, and leveling.

To the MAYOR, ALDERMEN, AND BURGESSES OF THE BOROUGH OF LEEDS:

——— the undersigned ——— ——— residing at ——— do hereby offer to execute the various works required to be done in paving, flagging, and leveling ———, in the borough of Leeds, at the prices affixed to each item in the schedule hereunto written; to find and provide all materials necessary thereto, and all labor requisite for completing and finishing the same in the most perfect manner, to the entire satisfaction of Mr. Thomas Hewson, the engineer and surveyor appointed by the council of the said borough of Leeds, on or before the time mentioned in the specification, and according to the forms and dimensions, and upon the terms and conditions detailed and set forth in the drawing and specification deposited at the office of the said Mr. T. Hewson.

In case this tender shall be accepted ——— do hereby agree to abide by and fulfill all the terms and conditions above mentioned, and to execute a contract in accordance therewith, and hereby propose Mr. ——— ——— of ——— as surety for the due performance thereof.

Schedule above referred to.

The following prices include all materials, labor, all excavation or filling, and everything connected with and required for the completion of the various works hereinafter mentioned:

Description.	Prices. English currency.	Prices. Equivalent in United States currency.
	s. d.	
New flagging, 3 inches thick, of the best Riven Bradford or Idle stone, knotted on face, well squared through, and laid down in mortar, on a bed of ashes 4 inches in thickness, properly rammed and prepared for the same, including rising in brickwork set in mortar, window areas, coal places, and all other openings where the height is less than 6 inches, per superficial yard	4 2	$1.01
Old flagging: Taking up, removing, resquaring, and relaying in mortar, on a bed of ashes 4 inches in thickness, including rising in brickwork set in mortar, window areas, coal places, and all other openings where the height is less than 6 inches, per superficial yard	1 0	.24
New straight curbs, 12 inches deep, 7 inches wide, in length of not less than 3 feet, of the best Bradford or Idle stone, including chamfered edge, per lineal yard	1 10	.45
New circular curbs, 12 inches deep and 7 inches wide, in lengths of not less than 2 feet, of the best Bradford or Idle stone, including chamfered edge, per lineal yard	6 6	1.58
Old curbs taking up, rejointing, and refitting, including chamfered edge, per lineal yard	0 5	.10
New sets, from Bradford or Bingley quarries, 8½ inches deep, well squared through and laid in asphalt, on a bed properly rammed and prepared for the same, per superficial yard	6 6	1.58
Old sets, taking up, redressing, removing, and relaying in asphalt, on a proper bed, per superficial yard	2 0	.49
New paving stones in cubes not less than 6 inches each way, from Bradford, Bolton Wood, or Bingley, laid in asphalt, on a bed of ashes 4 inches in thickness, including road forming, excavating, and leveling, per superficial yard	4 2	1.01
Old paving: Taking up, redressing, and relaying in asphalt, on a bed of ashes 4 inches in thickness, including road forming and leveling, per superficial yard	1 9	.43
Brickwork, set in mortar, to area grates, coal places, and all other openings, where the height is above 6 inches and 10 inches thick, per square yard	7 0	1.70
Cutting hole in landing and rebating to receive coal plate, each	2 3	.55
Rebating and fixing flap door and ash-pit plates, each	3 0	.73
Rebating in window grates, with lead run in, complete, each	2 6	.61
Fixing area grates (new pattern), each	1 0	.24
Reworking old landings, per superficial foot	0 3	.06
Reworking old steps, per foot run of step	0 3	.06
Fixing steps, each	1 0	.24
New thresholds, steps, or trapdoor frames, wrought, per cubic foot	4 0	.97
Six-inch landings for cellar tops, etc., complete, per superficial foot	2 6	.61
Fixing old landings and making water-tight with cement, per superficial foot	0 3	.06

Dated this —— day of ——— 188–.

(Signed) ——— ———.

NOTE.—No claim under the contract will be allowed which is not made in writing and within one month from the final measurement.

Directions.– No tender will be received except in this form.

The blanks must be filled up and the tender must be signed and inclosed in an envelope, indorsed "Tender for paving, etc.," and must be addressed to "The streets and sewerage committee, town clerk's office, Leeds."

LEEDS IMPROVEMENT ACTS.

Specification of certain works that shall be done in paving, flagging, and leveling ——— ———, in the township of ———, in the borough of Leeds, for the corporation of the said borough.

The works embraced under this specification are as follows, and shall be executed according to the drawings and instructions, and in every respect to the complete satisfaction of Mr. Thomas Hewson, the engineer and surveyor of the borough of Leeds.

Excavating and leveling.—The carriage ways and footways shall be carefully excavated, leveled, and formed to such level as shall be deemed by the borough engineer most convenient for the tenements abutting upon the street. The bed of the carriageway shall be made with a rise from the channels to the center of 1 in 30, and shall be cut out to a depth to allow a bed of 4 inches of clean, dry ashes, which shall be laid down to form the bed of the paving stones. The bed of the causeway shall be formed with a rise of 1 in 30, and shall be cut out to a depth that shall allow a bed of 4 inches of clean, dry ashes, which shall be laid down to form the bed of the flags. The superfluous earth or rubbish (if any) shall be led away immediately after completion of work. Should any hollow place require filling up, the same shall be done with dry and sound materials, well rammed. The price for doing all this work shall be included in the scheduled prices for paving, flagging, and curbing.

Paving.—The carriage way shall be formed of paving stones of the hardest stone, from the best beds in Bradford, Bolton Wood, or Bingley quarries, or of equal quality; entirely free from beds or flaws; in cubes not less than 6 inches each way, of uniform size, very neatly squared, and laid in regular courses from side to side, with fine cross joints, which must be kept perfectly clear to receive asphalt and coal tar-boiling hot; each stone must be laid with its natural bed in a vertical position; no stone will be allowed to be laid with its natural bed in a horizontal position on any account. The stones shall be well rammed, and all the joints shall be completely filled with a mixture of asphalt and coal tar, in approved proportions, run in boiling hot.

Curbstones.—The curbstones shall be of the hardest Nell stone, entirely free from beds and flaws, from the bottom beds in Bradford, Bolton Wood, or Bingley quarries, or of equal quality; they shall be 12 inches deep by 7 inches wide and not less than 3 feet long, and shall be firmly set on a solid bed in mortar. At the corners of the streets the flagging and curbstones shall describe a curve with a radius equal to the width of the footway. No circular curbstone shall be less than 2 feet long. The ends, tops, and sides of every stone shall be properly dressed and neatly boasted. When set the outer edge shall be neatly chamfered off for a width of an inch.

Channels.—The channels shall drop 4½ inches below the top edges of the curbstone, when the surface of the road has a natural fall to the gully grates; otherwise the channel must be constructed with a regular fall to take off the surface water which fall must be approved of before the channel is laid.

Flagging.—The flags of the footway shall be not less than 3 inches thick, of the best and hardest riven flags, knotted on face, from Bradford or Idle, or of equal quality, no dimension to be less than 18 inches. When the width of the causeway shall be 4 feet or less, every alternate course of flags shall go through the whole width. When the said width shall be more than 4 and up to 6 feet, not more than two flags shall be laid to every course; and where above 6 feet, they may be coursed two and three alternately. The joints shall be well broken in every case. All the flags shall be well squared, and the edges shall be properly squared through and dressed; they shall be laid in mortar on a solid bed of clean ashes 4 inches thick. No beddy flags shall be used.

Landings.—The landings shall be not less than 6 inches in thickness, of the best and hardest stone from Bradford or Idle, or of equal quality. When the width of the causeway shall be 5 feet or less, the landing shall go through the whole width, and if more than 5 feet, the landings shall be 3 feet square, if for a coal shoot, but if for cover to a cellar it must be the full width of the causeway. Each landing shall be properly squared, dressed, fixed, and made water-tight with cement.

Crossings.—The crossings shall be single sets of the hardest stone, entirely free from

beds and flaws, from the best beds of Bradford, Bolton Wood, or Bingley quarries, or of equal quality; laid down of widths corresponding to the footways. The sets shall be well squared and neatly dressed, not less than 8½ inches deep and 6 inches thick, laid in asphalt and tar, on a well-rammed, solid bed. The joints of the stones must be kept perfectly clear to receive asphalt and coal tar, boiling hot; each stone must be laid with its natural bed in a vertical position; no stone will be allowed to be laid with its natural bed in a horizontal position on any account. Two courses of inclined sets shall be laid parallel to the circular curb, so as to prevent any step in the causeway, and the crossing shall be so laid as to meet the level of the paved carriageway without break.

Brickwork.—The bricks to be machine made, of good quality, sound, well burnt, and sharp in the arrisses.

Mortar.—The mortar used throughout the work shall be composed of one part of the best Garforth quicklime to two parts of clean, sharp river sand, well mixed.

Asphalt.—The asphalt and tar shall be mixed in such proportions that the mixture shall, when cold, be tough and not brittle in any way, and shall be poured in boiling hot until the joints are well filled.

General conditions.

The contractor shall provide all implements and all materials (except only cast-iron work), and all labor of every kind necessary for the perfect completion of the works, and shall make good all damage done to water or gas pipes or other property in the execution of the works.

The contractor shall remove and cart away all the old paving, flagging, and other materials that shall not be allowed by the borough engineer to be relaid, or that shall not be claimed by the owners of property in the street.

The contractor shall remove all grates, taps, gutters, and other fittings at present existing in the street, and shall replace such of them as shall be suitable, and shall fix such new ones as shall be pointed out by the borough engineer. The iron work not refixed shall belong to the owners of property.

A rebate must be cut in the stonework to receive the front of all grates. The lugs to be let into stone-work and fastened with melted lead run in.

The contractor shall either always attend himself or shall employ a foreman, who shall be always upon the spot to direct the workmen; and the borough engineer shall have full power to discharge such foreman or any workmen should he or they disobey the orders of the borough engineer or conduct themselves in an improper manner.

The contractor shall provide a watchman and keep fires burning during the night in the said street, sufficient to protect the public effectually; and the said contractor shall be responsible for all accidents or damage which may occur at any time, either to person or property, in any way caused by any operations carried on in pursuance of his contract.

Wherever old paving, flagging, or curbing shall be found in the street that, in the opinion of the borough engineer, will suffice if relaid, the contractor shall redress and relay the same, as nearly as may be, in the same place.

The contractor shall distinctly understand that the works shall be throughout of the best materials and of the full sizes and thicknesses specified; and that the workmanship shall be first class.

The contractor shall give assistance in measuring up work, and net measurement only shall be taken, notwithstanding any local or other custom to the contrary.

No allowance will be made for rising window areas, coal places, and all other openings in the street where the height is less than 6 inches. The contractor must therefore carefully consider the nature of the work from inspecting the ground, and the plans and sections deposited at this office, before sending in his tender.

The contractor shall send in his tender upon the printed form supplied for this purpose by the borough engineer, as no other will be accepted.

Unskillful work or bad materials to be taken up and replaced.—If, at any period during the execution of the works, or within 6 months after their completion, it shall appear to the borough engineer that any work has been executed with unsound materials, or imperfect or unskillful workmanship, or if any repairs shall be considered necessary by the borough engineer during such period, arising from any sunk or damaged paving, flagging, curbs, or other works, that may occur from any cause whatever, whether arising from his own act, or the work of other parties, or of the workmen employed by the corporation, the contractor shall forthwith rectify, reform, and repair the same, in whole or in part, as the case may require, at his own proper cost and charge; and in the event of his refusing to do so, or to take back and remove any materials or articles which are considered by the borough engineer unsound, of bad quality, or not agreeable to the terms of the contract, and to provide immediately suitable materials in lieu of those condemned, within a period to be specified by the borough engineer, then the borough engineer shall have full power and authority forthwith to cause such imperfect work to be taken up and destroyed, and to employ other persons to alter or repair the same, and to supply the necessary materials thereto; and any expense thereby incurred shall be defrayed by the contractor, and may be deducted out of any moneys which may be due to him from the corporation, or may be recovered from him and his surety by the corporation (in the event of its exceeding the amount of moneys so due) as and for liquidated damages.

Bankruptcy of contractor.—That it shall be lawful for the corporation, in case the contractor shall fail in the due performance of any part of his undertaking, or shall become bankrupt or insolvent, or shall compound with his creditors, or propose any composition to his creditors for the settlement of his debts, or shall carry on or propose to carry on his business under inspectors on behalf of his creditors, or shall commit any act of bankruptcy, or shall not, according to the judgment of the borough engineer, exercise such due diligence and make such due progress as would enable the works to be completed within the time hereinafter mentioned, to determine the contract as far as respects its performance by the contractor, by a notice to that effect, in writing, but without thereby affecting the obligations and liabilities of the contractor, the whole of which shall continue in force as fully as if the contract had not been so determined, and as if the works subsequently executed had been executed by or on behalf of the contractor, and also without thereby creating any trust in his favor, and may enter upon and take possession of the works, and of all the plant, tools, and materials of the contractor, and use and sell the same as the absolute property of the corporation, and may proceed to complete the works, either by contract or otherwise, by engaging workmen and providing materials and implements, and may deduct the cost thereof from any sum or sums of money due or to become due to the contractor in respect of the contract, or recover the same by action at law or otherwise, as the corporation may be advised.

Disputes.—Any disputes which may arise during the progress of the works or at or after their completion, whether as to the meaning of the specification, or the materials, workmanship, or any other matters whatsoever relating to this contract, shall be referred to the borough engineer, whose decision shall be final, conclusive, and binding both on the corporation and the contractor.

Payments shall be made to the contractor by installments, as follows: When work to the value of £100 has been completed, 90 per cent. of the amount shall be paid within 1 week after the borough engineer shall have certified to that effect to the streets and sewerage committee of the council of the borough of Leeds; and so on by installments of not less amount until the whole be completed. The remaining 10 per cent. shall be paid after 6 months from the date of the last certificate, provided the borough engineer shall certify to the next ensuing meeting of the streets and sewerage committee aforesaid that the works are then in complete repair to his satisfaction, but not otherwise. The borough engineer shall have the power to refuse to grant a

certificate at any time, if the works are not progressing, being executed, or being put in repair, to his satisfaction.

Time.—The works shall be commenced as soon after the contractor's tender is accepted as the borough engineer shall order and, shall be completed within —— weeks after the said order has been given.

Penalty.—The penalty for noncompletion within the specified time shall be at the rate of £5 sterling for every week, or part of a week, that the specified period shall be exceeded.

THOMAS HEWSON,
Borough Engineer.

LEEDS, ———, 188—.

LEEDS IMPROVEMENT ACTS.

Tender for paving, flagging, and leveling.

To the MAYOR, ALDERMEN, AND BURGESSES OF THE BOROUGH OF LEEDS:

——, the undersigned, ——— ———, residing at ———, do hereby offer to execute the various works required to be done in paving, flagging, and leveling ——— in the borough of Leeds, at the prices affixed to each item in the schedule hereunto written; to find and provide all materials necessary thereto, and all labor requisite for completing and finishing the same in the most perfect manner, to the entire satisfaction of Mr. Thomas Hewson, the engineer and surveyor appointed by the council of the said borough of Leeds, on or before the time mentioned in the specification, and according to the forms and dimensions, and upon the terms and conditions detailed and set forth in the drawing and specification deposited at the office of the said Mr. T. Hewson.

In case this tender shall be accepted ——— do hereby agree to abide by and fulfill all the terms and conditions above mentioned, and to execute a contract in accordance therewith, and hereby propose Mr. ——— ———, of ———, as surety for the due performance thereof.

Schedule above referred to.

The following prices include all materials, labor, all excavation or filling, and everything connected with and required for the completion of the various works hereinafter mentioned:

	Prices.	
	English currency.	Equivalent in U. S. currency.
	s. d.	
New flagging, 3 inches thick, of the best riven Bradford or Idle stone, knotted on face, well squared through, and laid down in mortar, on a bed of ashes 4 inches in thickness, properly rammed and prepared for the same, including rising in brickwork set in mortar, window areas, coal places, and all other openings where the height is less than 6 inches per superficial yard	4 2	$1.01
Old flagging, taking up, removing, resquaring, and relaying in mortar, on a bed of ashes 4 inches in thickness, including rising in brickwork set in mortar, window areas, coal places, and all other openings where the height is less than 6 inches, per superficial yard	1 0	.24
New straight curbs, 12 inches deep, 7 inches wide, in length of not less than 3 feet, of the best Bradford or Idle stone, including chamfered edge, per lineal yard	1 10	.45
New circular curbs, 12 inches deep and 7 inches wide, in lengths of not less than 2 feet, of the best Bradford or Idle stone, including chamfered edge, per lineal yard	6 6	1.58
Old curbs, taking up, rejointing, and refixing, including chamfered edge, per lineal yard	0 5	.10
New sets from Bradford or Bingley quarries, 8½ inches deep, well squared through and laid in asphalt, on a bed properly rammed and prepared for the same, per superficial yard	6 6	1.58
Old sets, taking up, redressing, removing, and relaying in asphalt, on a proper bed, per superficial yard	2 0	.49
Macadam, per superficial yard	2 8	.65
New paving stones in cubes not less than 6 inches each way, from Bradford, Bolton Wood, or Bingley, laid in asphalt, on a bed of ashes 4 inches in thickness, including road forming, excavating, and leveling, per superficial yard	....	....
Old paving, taking up, redressing, and relaying in asphalt, on a bed of ashes 4 inches in thickness, including road forming and leveling, per superficial yard	1 9	.43
Brickwork, set in mortar, to area grates, coal places, and all other openings, where the height is above 6 inches and 10 inches thick, per square yard	7 0	1.70
Cutting hole in landing, and rebating to receive coal plate, each	2 3	.55
Rebating and fixing flap door and ash-pit plates, each	3 0	.73
Rebating in window grates, with lead run in, complete, each	2 6	.61
Fixing area grates (new pattern), each	1 0	.24
Reworking old landings, per superficial foot	0 3	.06
Reworking old steps, per foot run of step	0 3	.06
Fixing steps, each	1 0	.24
New thresholds, steps, or trapdoor frames, wrought, per cubic foot	4 0	.97
Six-inch landings for cellar tops, etc., complete, per superficial foot	2 6	.61
Fixing old landings, and making water-tight with cement, per superficial foot	0 3	.06

Dated this —— day of ——, 188—.
(Signed) —— ——.

NOTE.—No claim under the contract will be allowed which is not made in writing and within one month from the final measurement.

Directions.—No tender will be received except in this form.

The blanks must be filled up, and the tender must be signed, and inclosed in an envelope, indorsed "Tender for paving, etc.," and must be addressed to "The streets and sewerage committee, town clerk's office, Leeds."

SPECIFICATION FOR MACADAMIZING.

Form a ballast foundation, clean hard rubble pitching from approved, Potternewton or Woodhouse quarries, 12 inches thick in center and 9 inches thick at sides of road.

The pitching must be hand-packed on edge, the thickest and broadest end of stone laid downwards.

On this foundation form a layer of hard, clean broken stone, 3 inches thick above the general level of ballast. The stones to be broken to pass a 2½-inch gauge; carefully roll until firm, then lay top cover of best Threlkeld or other approved granite, 6 inches thick in the center of the road and 4 inches at the sides, well and evenly broken to pass a 2-inch ring, neatly formed to curve of road; the whole must then be thoroughly rolled with a steam roller. (The highways committee will grant the use of their roller, which must be paid for by the contractor at the usual rate.)

The rolling must begin at the sides and gradually proceed to the middle of the road. It must be accompanied by a water cart and all hollows that may appear on the surface as the rolling proceeds must be filled in with small stones, and the surface loosened for this if necessary.

When the stone is firmly wedged together, fine, clean, dry gravel, or dry macadam road sweepings must be spread with a shovel uniformly over the surface in small quantities, and must be thoroughly rolled into the road with the aid of watering and sweeping, fresh binding being added as that first applied works in or is found necessary.

The crown of the road when finished must be not less than 3 inches above the curb level.

Form the channel 18 inches wide of courses of best Bradford or Bolton sets, 8 inches deep, laid and set on a bed of screened engine ashes, 6 inches thick, the whole to be well squared, and neatly dressed and run with boiling asphalt until the joints are entirely filled.

The following is the statement previously referred to as received from Mr. T. A. Prince, highways surveyor, borough of Leeds:

INFORMATION AS TO ROADS AND STREETS IN THE BOROUGH OF LEEDS.

Materials used for paved streets of heavy traffic: Granite sets 6 inches deep, 7 to 8 inches long, 3 inches wide. These sets are in every case laid on a bed of cement concrete 9 inches deep. Cost, complete, of concrete paving and granite sets, about 14*s.* per superficial yard ($3.41).

Materials used for paved streets of light traffic: Gritstone pavors obtained from quarries in Yorkshire. Size, 6-inch cubes laid on a bed of ashes only. Cost of paving complete, about 4*s.* per superficial yard (97 cents).

Cost of making macadam roads for heavy traffic, with granite broken to a 2½-inch gauge purchased by the corporation from the various granite companies in England and delivered by the said companies at the various railway stations as required, and afterwards carted by the corporation from the said stations to wherever required throughout the borough, is about 2*s.* 11*d.* per superficial yard (71 cents).

Cost of making macadam roads for light traffic with limestone or dross broken to a 2½-inch gauge is about 2*s.* per superficial yard (49 cents).

Entirely new streets are sewered, paved, and flagged at the cost of the owners of property on each side of the road and afterwards declared public highways and maintained by the corporation forever out of a uniform highway rate assessed throughout the borough.

In a majority of cases throughout the borough flagged footways are laid on each side of the road. The total width of these footways is one-third of the full width of the road, *i. e.* a 36-foot road equals two 6-foot causeways and 24 feet of roadway.

Cost of curbing per lineal yard, about 3*s.* 2*d.* (77 cents).

Cost of flagging per superficial yard, about 4*s.* 3*d.* ($1.03).

In making an entirely new macadam road we pitch the foundation to a thickness of 8 or 10 inches and afterwards put on a covering of metal about 7 inches thick.

Supervision.—In Leeds there are close upon 300 miles of paved and macadam highways, the management of which is under one central department.

We have eight outdoor inspectors who have under their charge a staff of men numbering from 20 to 30. These inspectors overlook nearly 40 miles of highways, and their duties comprise the looking after the men, the putting on of materials, and the rolling of the same.

Experience has proved that in numerous cases within the borough of Leeds whenever a new road has been made or an existing road widened and improved the value of the land adjoining the same has wonderfully increased.

With regard to the country roads within the borough of Leeds there are very few which have not the footways properly formed with curbstones and channel.

F. H. WIGFALL,
Consul.

UNITED STATES CONSULATE,
Leeds, December 10, 1890.

BIRMINGHAM.

REPORT BY CONSUL JARRETT.

CITY STREETS.

In the city of Birmingham there is something over 200 miles of public streets, of which 7 miles have the carriageways paved with wood, about 24 miles with granite, and the remainder are macadamized.

For the wood-paved streets 3-inch by 6-inch creosoted yellow deal blocks are used, being laid on a 6-inch bed of Portland cement concrete. In the construction of these roads care is taken to have the ground dry and firm before the concrete is laid on. A very thin coat of cement or a mixture of cement and clear sand is placed over the concrete so as to have the surface perfectly even, which is left to stand for several hours and when dry the blocks of wood are finally laid on, over which heated pitch or a mixture of heated pitch and tar is thrown so as to fill up all the crevices between the blocks.

The first cost of these at present is about $2.68 per square yard. The Improved Wood Pavement Company (a London corporation constructing this kind of road throughout Great Britain) maintain these roads whereon there are not any tramways (street railways) for 1 year free of charge and for 20 years thereafter at prices varying with their situation from 15 cents to 18 cents per square yard per annum. On tramway routes the company is paid at a rate of 24 cents per square yard per annum for maintenance between and for 21 inches on either side of the metals, the first cost remaining the same.

For granite-paved streets, Leicestershire or Carnarvonshire sets 3 inches in width by 6 inches in depth are generally used, being placed on 6 inches of Portland cement concrete. In the construction of these roads great care is taken to have the foundation good and firm. The first cost of these is about $2.92 per square yard. The repairs for the first 7 years are practically nil, for the next 7 years from 6 cents to 14

cents per square yard per annum. In the heaviest traffic streets the paving would probably then require relaying at a cost of about 73 cents per square yard, when it would last under similar conditions another period of 14 years, and the best of the stone might be then redressed and used in second or third class streets, and the remainder be broken up and used for macadamizing purposes.

It will be observed that the first cost of construction is very large when compared with the cost of relaying with new blocks. This is due to the great care taken in preparing the roadbed for the blocks in the first case. Such a roadbed may last, if properly constructed, for a very long period. I have very carefully investigated the matter but have not yet found a single case in which granite blocks are placed on a bed of loose sand or gravel, which is so commonly done in the United States. First cost may be heavy in this country but cost of maintenance, it will be observed, is comparatively very light.

Then there is the advantage of good, even roadways, over which the heaviest loads are easily and conveniently conveyed. I have seen breakdowns on the streets of this city through overloading or defective axles, but so far have not seen wheels of wagons stick in a hole between granite blocks or between blocks and the metals of the street railways.

For newly made macadamized streets, assuming that the ground has been roughly formed, about 9 inches of ashes are required over which 8 inches of either gravel or broken slag, is placed and over this again is placed 6 inches of broken rowley rag stone which is obtained about 7 miles outside the city. Large heavy iron rollers are then passed over the stone surface. During this process water is applied, and about an inch of clean gravel is worked into the surface.

The first cost of such roads may be taken at about 73 cents per square yard. The maintenance thereof varies very much according to the traffic, and it is found economical to substitute pavement for macadam if two coatings of stone are required annually.

JOHN JARRETT,
Consul.

UNITED STATES CONSULATE,
Birmingham, February 13, 1891.

HULL.

REPORT BY CONSUL DANIELS.

GRANITE PAVEMENTS.

Granite and wood pavements and macadamized roads are used in this city and district. The work is done by contract under the direction of the borough engineer.

In granite pavements the surface for the foundation is formed parallel with the finished surface of the road and at the required depth below

the same. The foundation of the carriageway extends under the curbs and channels and consists of a layer 7 inches in thickness of cement concrete, composed of clean broken brick, stone, or coarse gravel, of such size as will pass in any direction through a ring 2½ inches in diameter, together with such quantity of other suitable fine material as will make up the interstices, and Portland cement in the proportions of one of cement to eight of the other materials. The whole to be well and carefully mixed with the proper quantity of water, the materials being hacked gradually down and watered on a platform, and being turned over at least three times in such process.

Existing foundations are utilized when suitable, all loose material being removed from the surface when necessary by the addition of fresh concrete. The whole surface of the foundation is covered to a depth of from 1 to 2½ inches as required to level the surface, with fine concrete as a bed for receiving the sets, which are laid while the concrete is soft, and must be well bedded therein, and no greater area is covered at one time than can be easily paved before the same has set.

The sets are carefully sorted out and selected as nearly as possible of equal depth, so as to run in parallel courses, the entire width of the roadway and the courses are arranged throughout so that the sets in each course will break joint well and evenly with those in the adjoining courses, and the sets are placed close end to end; the closing as well as the commencing stones adjoining the channels and tramways, if any, being alternately long and short. The courses are laid as close as possible together, the joints at no point exceeding ¾ inch in width.

Great care must be taken to adhere to the camber, and all necessary templates must be used to secure this. The rammer must be used as little as possible, and any set above or below the required level must be taken up and reset. When the fine concrete has set hard, the interstices in the paving must be well raked in full to the top with small, clean shingle of good quality, free from sand and perfectly dry, and as soon as possible after the joints have been filled with shingle, they must be run up full to the top, while dry, with asphalt, which is composed hereof coal-tar pitch and thick boiled coal-tar, from which the spirit has been extracted, in proper proportions, the whole boiled together for such a period as may be necessary to cause the mixture to set hard and stiff when cold, without being brittle, and to be whilst hot, sufficiently fluid to fill all the interstices in the shingle. No joints are run with asphalt until the laying of the pavement has been approved by engineers. As soon as the asphalting of the joints is completed, the whole surface of the pavement must be covered evenly and uniformly with approved dry gravel, which must be laid on before the asphalt is quite set, so as to become partially bedded therein. The crossings are paved in a similar manner with sets provided for the purpose.

WOOD PAVEMENT.

In wood pavement, which gives much satisfaction in this country, a foundation of cement concrete is formed, 7 inches in thickness, composed as described in granite pavements.

Its surface is faced with half an inch of cement, mixed in the proportion of one measure of cement to three of sand, formed to the proper camber and inclinations, and smoothed so as to form an accurate bed for the wood blocks.

The blocks of wood are sawed die-square from redwood, 9 inches by 3 inches by 5 inches, the grain of the wood running with the 5-inch measurement, and equal to the samples deposited for inspection. After the blocks are cut up, the contractor must give notice to the engineer in order that he may inspect them, and when the engineer has approved them, they must be creosoted with 12 pounds best creosote to the cubic foot.

Two courses of wood blocks are laid parallel to and adjoining each curb, and the remainder in courses running transversely to the street, and the blocks in the courses are placed close end to end, those adjoining the channel being long and short in alternate courses.

The courses themselves are three-eighths of an inch apart, the proper distance being maintained by laths laid on the cement. The joints are filled up with shingle to a level of 1 inch below the surface, and run up with asphalt, as for set pavement, to such level, care being taken to allow no asphalt to run over the surface of the blocks.

The remaining inch of the joints is run up with cement-grout mixed in the proportions of one of cement to two of sand, and the whole surface is then covered with fine gravel.

MACADAMIZED ROADWAY.

The surface for receiving the foundation material for macadamized roads is formed parallel with the finished surface of the road and at the required depth below the same.

Where the existing surface is raised the material must, if required by the engineer, be watered and rolled or rammed.

The foundation of the carriage way consists of a layer of hard chalkstone or other material accepted by the engineer, 8 inches in thickness, broken into sizes not exceeding that of a 4-inch cube, and into smaller pieces on the surface as required to fill the interstices, and properly rolled, and such layer is to extend under the channels and curbs. The next coating consists of a layer of granite, or other suitable material, broken to pass in any direction through a 2½-inch ring, of a thickness before being consolidated of 2½ inches, and such coating to be rerolled until set. The coating is to be formed to a proper camber, making the crown, in the case of a roadway 24 feet wide, 1 inch above the curbs.

The surface covering consists of a further coating of whinstone,

broken to pass in any direction through a 2½-inch ring, of a thickness before being consolidated of 2½ inches, such coating being covered with gravel and rolled in a similar manner to the previous one.

As to maintenance, a paved road is repaired in a similar manner to that in which it is first made.

A macadamized road in town is hacked over, spread with a sufficient quantity of broken whinstone to raise it to its proper level and camber, and rolled with a steam roller, just sufficient binding material being used to fill the interstices in the larger material. The binding material generally used is a somewhat loamy gravel.

On country roads the old surface is not hacked over, nor is the new material rolled, but is left to be consolidated by traffic.

SYSTEMS AND COST OF ROAD MAKING.

The roads are under the control of the city or borough engineers. As the same staff also deal with drainage and architectural work, I found it impossible to separate the office expenses chargeable to highways.

PUBLIC EFFECTS OF IMPROVED ROADWAYS.

I have not been able to get sufficient information which would enable me to give a satisfactory reply to this query.

BYRON G. DANIELS,
Consul.

UNITED STATES CONSULATE,
Hull, December 30, 1890.

LONDON.

REPORT BY CONSUL-GENERAL NEW.

As directed in Department's circular, dated November 8, 1890, I have the honor to submit herewith a report upon the subject of the streets and highways, and of their construction and maintenance in this consular district.

I am fortunate to be able to obtain and inclose herewith the reports of William Haywood, esq., engineer and surveyor, to the honorable commissioners of sewers of the city of London, for the years 1873, 1874, 1877, and 1882, upon the condition of the streets and pavements of the city of London.

The streets and pavements of the city of London are under the control of the commissioners of sewers, and Mr. Haywood has been their engineer and surveyor in charge for many years.

I was also fortunately able, through the great kindness of William Weaver, esq., engineer and surveyor to the vestry of the parish of St. Mary Abbotts, Kensington, to obtain from him a most able and full and

elaborate communication upon the merit of the various kinds of streets and pavements under the charge of that vestry, which includes that part of the metropolitan London called Kensington; and I wish to acknowledge to that vestry their very great kindness, and to Mr. Weaver my sincere thanks for his most valuable communication.

I also inclose herewith the thirty-second and thirty-fourth reports to the vestry of St. Mary Abbotts, which include much information upon the subject in hand.

I also inclose a valuable communication from James R. Heward, esq., surveyor, etc., to the board of works of the Greenwich district of the city of London, upon the subject, together with printed copies of the specifications for making the various kinds of streets, pavements, and roads in that district.

From these reports and communications may be learned the original cost of the various kinds of pavements used in London, as also the annual cost, through a series of years, of the maintenance of the several kinds, and another valuable report on the accidents to horses and vehicles upon each kind of street in the varying conditions of the weather.

These reports, being authentic and official, and made as those are by these eminent engineers of so many years' practical experience and observation, are vastly more valuable and reliable than would be a report made by a non-expert in such matters, and, I believe, fully answer the inquiries of the circular so far as my immediate consular district is concerned.

I desire to express herein my thanks to these several gentlemen for their great kindness in providing these reports and communications.

JNO. C. NEW,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
London, January 3, 1891.

THE STREETS OF LONDON.

Mr. Weaver, chief engineer and surveyor, to Consul-General New.

TOWN HALL, *Kensington, December* 15, 1890.

SIR: The Kensington vestry at its meeting on the 10th instant considered your letter asking for certain information on the subject of roads, and issued a general instruction to their vestry clerk and surveyor (myself) to furnish you with information on the subject.

In obedience to the instructions above referred to, I hasten to discharge my part of the reference.

Your letter to me of the 5th instant specified four heads of information, and I proceed hereunder to deal with them in the order of your enumeration, prefacing my remarks by pointing out that the information hereinafter set forth is of a general character, susceptible of detailed treatment to an almost unlimited extent, but involving in such elaborated treatment an amount of labor impossible of bestowal within the limits of the vestry's instruction.

I now proceed to deal with the several heads of information.

(1) The methods employed in making and maintaining public roads in Kensington. There are about 84 miles of roads in Kensington paved with wood, asphalt, pitching, broken granite (macadam), flints, and gravel. All the main roads are paved with wood except about 1,000 square yards of asphalt. The whole of the wood paving is laid on a foundation 6 inches thick of concrete composed of Thames ballast and Portland cement mixed 6 to 1. This foundation is sufficient, provided there is a good solid substratum beneath; where such solidity does not exist extra concrete should be provided. The concrete is worked to a perfectly smooth face, and when hard set the wood blocks are laid thereon in transverse rows. Over 200,000 square yards of wood have been laid in Kensington, and I have tried various kinds of wood, including the ordinary fir deals, beech, vale, and jarrah, cut to depths varying from 3 to 6 inches, and have laid the blocks in a variety of ways close together, with open joints grouted with different materials, with felt joints laid on asphalt and on felt, plain deal blocks, creosoted blocks, naphthalized blocks, etc., etc.

The figures and details appertaining to the various experiments in this one description of road work would make a good-sized pamphlet, but the result to the present time in Kensington is that we are laying down creosoted deal blocks 9 inches by 3 inches by 5 inches deep (on concrete as aforesaid) generally with open joint three-eighths inch wide, filled with asphalt to a depth of one-fourth or one-half inch, and remainder of joint grouted in with Portland cement grout. Sometimes the wood is laid close without any joint, and if the weather (dry) permits this to be done the result is good. The success of creosoted wood depends upon the quality of the creosote and the thoroughness of the creosoting. By the method I employ this is assured. My table of results shows about 10½ pounds of creosote forced into each cubic foot of wood laid.

Herewith I have forwarded copies of my two last annual reports, and you will see therein (amongst other information which may be of service) that the greater part of the wood laid is 6 inches deep.

Of late years, however, 5-inch blocks have been used and in one thoroughfare, Sydney place and Onslow square, 4-inch blocks have been laid down, and it is very likely that a few years hence blocks deeper than 4 inches will not be used. The object of reducing the depth is to save the great waste of wood when the road is repaved. With 6-inch blocks there is about 3 inches of wood wasted consequent on the necessity of repaving, when 3 inches of the contour of the road has been worn away, as the side channels, unaffected by traffic, retain their original levels.

A road wood-paved with 5-inch creosoted deal blocks will last 10 years, and at present prices will cost 1*s.* 6*d.* per square yard per annum for first cost and reparation throughout that period; the concrete included in the first cost will remain as an unencumbered asset to be taken over for the next term. The first cost of excavating for and providing concrete foundation may be taken at 3*s.* per square yard.

Scavenging is not included in foregoing cost of maintenance.

In my opinion wood paving is at present the best paving for the main roads of a district such as Kensington. In a nonresidential commercial district, such as the city of London, I should give the preference to asphalt, which can be laid at a first cost of about 11*s.* per yard, or laid and maintained for 15 years at an annual cost of about 1*s.* 6*d.* per yard, but the price would vary according to traffic.

The essential requirements of wood and asphalt paving is cleanliness—thorough cleansing. Washing and sweeping every night, if necessary, and the prompt removal or picking up of horse droppings during the day. One of the great difficulties is the removal of the sludge formed on wet days. This I effect by wide india-rubber squeegees, the slush being forced into large iron gully pits under channels and cleaned out and carted away during the night. In Appendix A you will find this iron gully (which I designed) described, and I may add that since the date of that report the said gully has proved so successful that I have extended their use considerably.

With reference to pitched roads in Kensington, this paving is almost exclusively confined to mews, stable yards, and tram lines. Mews are generally paved with 4-inch by 4-inch cubes on 6 inches of concrete; tram lines with 6-inch by 3-inch pitchers on concrete, and pitched roads for heavy traffic with 9-inch by 3-inch pitchers on concrete. The greater dimensions of the pitchers represent the depth of the stone.

Without doubt the most durable road is one formed of granite pitchers. The great objection to their use is the noise. For heavy traffic roads, with steep gradients, pitching is the best and most economical road paving, especially if granite tram-wheel tracks are provided.

With regard to roads made and repaired with broken granite, flints, and gravel, it is essential in the first place to provide a good foundation. My specifications always provide for a consolidated foundation 18 inches thick of good brick rubbish or hard core, and spread thereon a consolidated coat 9 inches thick of Kentish flints or gravel (as the case may be) or of broken granite. With the last-mentioned material a consolidated coating 4 inches thick will generally suffice. The consolidation is effected by steam rolling. I use broken granite of various descriptions, broken to various gauges, 1¼ inches to 2¼ inches, using the smaller gauge in light carriage roads and the larger in roads traversed by omnibuses. In my opinion, the most pleasant road to travel upon and easiest to maintain is a well-formed gravel road; but, of course, this kind of road is out of the question beyond a certain traffic point.

(2) The details of the systems followed and expenses incurred respecting same.

I take it that a great deal of the information embodied in the answer to question No. 1 will also apply to this question. In addition I may add that the work of making new roads (of all kinds) and the supply of all materials for the reparation of existing roads, is executed and carried out, under specifications prepared by me. Tenders are invited by advertisement for the new work as it arises, and for the supply of materials, annually. The maintenance, scavenging and watering, is executed by the vestry's own staff, consisting of about 450 men, 100 horses, and about 150 carts and wagons. All the carts, etc., are made in our own workshops, blacksmiths' and harness work is also performed by vestry's own men. The foregoing staff also performs the work of house refuse collection and removal. The house refuse (dust, ashes, etc.), and street refuse (mud and sweepings), amounts to about 100,000 tons annually. It is collected by the carts and deposited in barges on the river and Grand Junction Canal. In relation to this refuse the scheme of the vestry is to utilize it for agricultural purposes, and with this object, land at Purfleet (17 acres) has been acquired, but as this scheme is only just being entered upon, it is too early to form an opinion relative thereto, based on facts. I may add, however, that my views on this subject are not in accord with those of the majority of the vestry, and are set forth in the series of reports hereto attached in Appendix No. 2.

(3) The effect of improved public roads upon land values and other economic conditions.

This is a very wide question upon which I could write a very long essay, but speaking generally, it is beyond question that the formation and maintenance of good roads increases the value of land in a district and adds to the rental value of the houses. If the governing authorities of a town or district, by good management, make such district a nice comfortable place to live in, people will flock to it in added numbers, convert agricultural land into building land and increase the trade.

In 1856 the roads in Kensington maintained by the vestry, were 23¼ miles in length.

The greater portion of the district was market-garden ground, now covered with mansions and houses from £100 to £1,000 a year rental value.

At the present time in Kensington there are about 84 miles of road maintained by the vestry; the population is 179,720, and the gross rateable value of the parish is £2,390,728 (net, £1,999,682).

Shops in the High street, then letting at £80 and £100 per annum, now command £500 a year, with heavy premiums.

This change has not, of course, *all* been brought about by parochial management. Proximity to the parks, etc., has had a good deal to do with the change, but the parks, etc., existed, I may say, for centuries prior to the change, and I am certain of this, that wealthy people will not continue to reside in a district where sanitary requirements are neglected, refuse allowed to collect in houses, bad roads provided for traveling, and neglected lighting, watering, and scavenging allowed to prevail.

(4) Such other information as may be germane to the general subject of improved public roads.

Under this head may properly be considered the questions of subsoil, and the rights of companies and others to lay mains, pipes, electric and telephone wires, etc.

The functions of the vestry in relation to road making commence as soon as vacant land is proposed to be laid out for building.

Formations of roads. (25 and 26 Vic., C. 102, S. S. 98 and 99; 45 Vic. C. 14, S. S. 7, 8, 9).—The first step in the transformation is to submit duplicate plans to the London county council, showing the road proposed to be formed or laid out and setting forth the widths and levels of same. One of the said duplicate plans is forwarded to the vestry for their opinion, which guides in a great measure the decision of the London county council. Under the 98th and 99th sections, 25 and 26 Victoria, Cap. 102, and the 7th, 8th, and 9th sections, 45 Victoria, Cap. 14, very full powers are conferred upon the Metropolitan board of works (now London county council) enabling them to control this initial stage of the development.

The council can refuse to sanction a street with a less width than 40 feet, or with less than two outlets; and by the increased powers given under the last-mentioned act, they can require the roads to be formed in such directions as to secure convenient intercommunication with adjoining roads. This power, although guarded by a proviso giving a right of appeal to a police magistrate, in order to check unduly arbitrary treatment by the council is an extremely salutary one, as it tends to prevent the isolation and locking in of estates to the detriment of the public convenience. Although in certain circumstances the council's powers may conflict with the right of the freeholder to do what he likes with his own land, still it is only just that the owner, in increasing some forty fold the value of his ground, should in some degree have to study the interests of the public, to whom the land owes its increment of value. Had this act been in force years back it would have prevented estates being laid out to the detriment of public intercommunication.

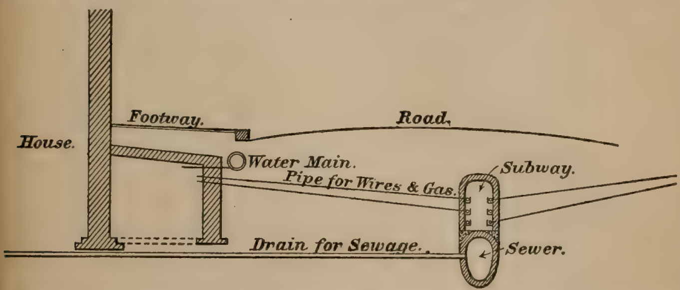
The plan of the proposed roads having been approved, the formal consent of the council is given, with the condition attached that no bars or obstacles to the free use of the roads by the public are at any time to be erected. This condition has only of late years been appended; but it is a most wise one, as it prevents the existing nuisance of gate-barred streets. A bill, seeking powers to abolish barriers now in existence, is before Parliament, and if enacted will confer great benefit, but doubtless will entail considerable public expense. Had the law, as it now stands, been the same in the past, this compensation for removal would not have to be paid.

The owner having obtained the approval of the council, who, at the same time, name the street, may proceed with its foundation, and now the anxieties of the surveyor to the local authority commence. If zealous in the discharge of his duties, he is desirous that the road shall be formed in such a manner as to be a safe and convenient highway for public traffic, and that it shall contain nothing concealed below the surface likely to jeopardize the health or safety of the future abutting residents, or the public passing thereover. He has in the first place to see that the full width is set out, and then that the proper level is observed. Very little difficulty arises on the first point, and the second question of level should have received full thought when the plan was before his vestry for consideration, as it is essential that new roads on one estate should be laid out at such level and incline as conveniently to intersect and join with other roads formed, or to be formed, on adjoining estates. The proper levels having been determined after due consideration, it only remains to

enforce them, and although the heights of all intersecting streets are set out by the vestry's surveyors, and the value of such heights above ordnance datum furnished to the builders, yet it is no unusual thing, upon the vestry proceeding to make up the street some year or two afterwards, to find the houses erected at different heights with an utter disregard of the intersecting levels furnished as aforesaid, leaving to the surveyor the interesting problem of how to adjust the paving and road levels to the varying heights of the areas and steps with the minimum of injury and disfigurement to the property. In clay lands I find the tendency is to make the roads too high; and in sand and gravel soils, too low. In the former the surplus clay has to be carted away at considerable expense, while in the latter every load of sand and gravel excavated means increased profit.

By the sixth section of the metropolis management act, 1890, the abstraction of subsoil is prohibited from the site of any road formed or proposed to be laid out, and no road is to be formed upon made ground, except under conditions to be imposed by the local authority, subject to appeal to the London county council. This new law will add materially to the stability of future roads, and to the safety of pipes, mains, drains, etc., laid in them.

Gas mains, electric light and telephone wires, I am of opinion should be laid in subways. In old streets, the initial outlay is the great hindrance to their adoption, but in forming new streets this difficulty to a great extent does not exist. By forming a subway over the sewer when it is being built the only extra cost is the brickwork; all the excavation is necessitated by the sewer, and by laying side pipes in the drain trenches nearly all the expense of the side connections is saved.



The water mains I should lay in footways. As the sewers are rebuilt, I should add the subways, and thus, at any rate within a 100 years, subways would be universal. If this process of gradual provision were deemed too slow or tedious, it might well be considered whether it would not be well to raise a "subway loan" to provide the capital expenditure. Taking such a loan at 3 per cent. for 50 years and the cost of subway at £10,000 a mile, I think it would be practicable to charge such a rent for its use as the companies would be glad to pay and such rent would repay the capital expenditure within the life of the subway. The public authorities would thus save the loss caused by the incessant disturbance of the highways, and the public themselves would be saved the inconvenience attaching to such incessant disturbance. With regard to above estimate of £10,000 a mile, the cost would be about half this amount if the subway was formed with the sewer.

Referring generally as to question No. 4, I would advise that the roads of a district should be made in relation to the traffic upon them, and paved with the most suitable material, having due regard to all the circumstances attaching to such road. In Kensington before any road is made up or converted, I submit a report and estimate which generally guides the vestry in its action.

With regard to your inquiry as to books of reference, I am sorry I can not help you in that respect. I have never studied books. I have gone about a good deal, and my

views, as hereinbefore set forth, are the outcome of 31 years practical experience, and if the information I have roughly tried to convey in a concise form does not prove too prolix for your patience, and does prove of some service to your department, I shall be well satisfied.

If you would like to see me, or desire further information, pray command

Yours faithfully,

WILLIAM WEAVER, C. E.,
Surveyor, Town Hall, Kensington.

General J. C. NEW,
Consul-General of the United States of America,
12 *St. Helens Place, Bishopsgate Street, E. C.*

STREET AND HOUSE REFUSE.

[Appendix to Mr. Weaver's report.]

PARISH OF ST. MARY ABBOTTS, KENSINGTON.

VESTRY HALL, KENSINGTON,
Surveyor's Department, March, 1880.

To the WHARVES AND PLANT COMMITTEE OF THE VESTRY OF KENSINGTON:

GENTLEMEN: In accordance with the directions of the vestry, instructing me to report on the slopping work of the parish of Kensington, I have prepared and beg to submit the following remarks. For reasons which will be obvious after a consideration of the following pages, I have found it necessary and advisable to deal conjunctively with the subject of dust collection.

The committee will recollect that prior to the vestry undertaking the execution of the parish work, in 1877, the cost of slopping and dusting had been increasing annually, and when in February, 1877, the tenders for these works were opened, such largely increased amounts were demanded that the vestry resolved at once to take the work into their own hands.

Acting energetically upon the foregoing resolution the vestry, on the basis of a report and estimate which I had the honor of submitting, obtained the necessary plant and premises, and from that period have carried on the work until the present time, in a much more satisfactory manner than under the old contract system, and at the same time at less cost. Owing, however, to causes hereinafter referred to, the work each succeeding year becomes more costly and difficult of execution, and unless prompt and effective measures are adopted, the time, in my judgment, is not far distant when the vestry will find itself in serious difficulties, with the present available means of escape therefrom then closed or only to be acquired at vastly increased cost.

With a firm conviction that a large amount of the present cost of work may be saved, and with the future difficulties of the work plainly apparent, I beg to submit and place on record the views I entertain with respect to the subject on which I am directed to report.

The accounts of the vestry for the past 3 years, during which the work has been performed by the vestry's own staff and plant, furnish only the total expenditure for the entire work theretofore executed under contracts and do not give the separate cost of any one particular branch thereof. It thus being impossible to ascertain the value per day of a horse and cart engaged on any one particular work, I have, in the subjoined statements, taken the value of the horse labor herein referred to; the totals given as the cost of the work must, therefore, be taken as comparative estimated amounts and not as actual totals of expenditure. The deductions and inferences, however, drawn from the rates and amounts tabulated, would be but very slightly altered by a reduction or increase of a shilling in the assumed rates per day.

STATEMENT I.—*Road sweepings.—Number of loads removed, amount of labor employed in removal, and estimated cost of same.*

During the year ending Lady Day, 1879:	
Number of loads removed	32,706
Horse, cart, and man, at 13*s.*, number of days	6,981
Total cost of collection and shoots	£5,290 19*s.* 6*d.*
Amount paid for shoots	£753 6*s.* 6*d.*
Net cost per load for collection and shoots	3*s.* 3*d.*
Average number of loads per day per horse and cart	4⅝
During 9 months ending Christmas, 1879:	
Number of loads removed	20,252
Horse, cart, and man, at 13*s.*, number of days	5,096
Total cost of collection and shoots	£3,467 9*s.* 9*d.*
Amount paid for shoots	£155 1*s.* 9*d.*
Net cost per load for collection and shoots	3*s.* 5*d.*
Average number of loads per day per horse and cart	4

STATEMENT II.—*Dust and ashes.—Number of loads, labor, and cost of collection.*

During the year ending Lady Day, 1879:	
Number of loads collected	25,567
Dust, cart, and dustman, number of days, at 14*s.* 9*d**	10,180
Gross cost of collection	£7,507 15*s.* 0*d.*
Amount received for dust†	£3,837 16*s.* 0*d.*
Net cost of collection	£3,669 19*s.* 0*d.*
Net cost of collection per load	2*s.* 10½*d.*
Average number of loads per day per cart	2½
During 9 months ending Christmas, 1879:	
Number of loads collected	19,914
Dust, cart, and dustman, number of days, at 14*s.* 9*d**	7,352
Gross cost of collection	£5,422 2*s.* 0*d.*
Amount received for dust†	£497 15*s.* 0*d.*
Net cost of collection	£4,924 7*s.* 0*d.*
Net cost of collection per load	4*s.* 11½*d.*
Average number of loads per day, per cart	2$\frac{7}{10}$

As the committee have decided that the collection of dust can be performed more economically by having one dustman to two dust carts, rather than by having a dustman with each cart, in addition to the cartman, it assumed in the preceding statement that the whole of the carts have been worked on the preferential plan.

It will be seen on reference to the two statements, that nearly 60,000 loads of refuse have annually to be collected in the parish and carted away, a work of great magnitude, involving a heavy expenditure.

The cost of the work depends, in a great measure, on the distance to which the refuse has to be carted; for instance, if during the 12 months ending Lady Day, 1879, the slop carts had been enabled to deliver, on an average, 6 loads each per day, instead of 4⅝ (Statement I), a saving in that work alone would have been effected, amounting to £1,758, assuming that the shoot was the property of the parish, and the committee will perceive from the same statement that the net cost per load was 2*d.* less during this period, compared with the following 9 months, although the shoots were costing nearly four times more in the former than in the latter period.

During the same year (12 months ending Lady Day, 1879 (Statement II), the dust realized a large sum of money, an amount which it is not likely to produce in the

*Horse and cart, ladders, baskets, tools, etc., 9*s.*; Carter, 4*s.*; Moiety of dustman's wages, 1*s.* 9*d.*; total per day, 14*s.* 9*d.*

†The dust delivered under agreement of sale is taken as all being paid for.

future. Leaving out, therefore, that exceptional time from this calculation, and taking the return for the 9 months ending Christmas, 1879, we have a total of 19,914 loads delivered, giving an average of $2\frac{7}{10}$ loads each cart per day. If nearer shoots had been provided, enabling the carts to deliver 4 loads each per day, a saving of £1,252 would have accrued upon the net cost, and calculating the saving during the remaining 3 months of the year at the same ratio, the total saving in the 12 months would be £1,670. This amount added to the reduction in slopping (£1,748), above referred to, gives £3,418 as the total amount which might be fairly expected to be saved in 1 year by the acquisition of handy shoots. Such saving, however, could only be effected on this important condition, viz, that the refuse, when once deposited, should not involve any further net expense to the vestry, but should, after its reception, be made at least to pay for itself.

This condition, which I believe can be more than fulfilled, necessarily leads up to the subject of the best means of disposing of and utilizing the refuse, in order that it may be made at least to pay for itself, and thus fulfill the condition referred to.

In the first place, a large amount of material has to be dealt with, viz, 60,000 loads per annum, which may be taken as over 90,000 cubic yards. The question, then, for consideration is the best method of dealing with 58,000 cubic yards of slop and road sweepings, and 40,000 cubic yards of dust and house refuse.

The road refuse consists of sweepings from—

First, macadamized roads; second, flint and gravel roads; and third, wood-paved roads.

The first mentioned is composed of particles of granite, more or less small, horse droppings, water, and litter. The particles of granite and horse droppings could be eliminated by screening the slop mixed with added water; the fine particles of granite-like sand would settle, and the water, almost clear, could then be drawn off for reuse. The first screenings, *i. e.*, granite and horse droppings, would be dried in an oven attached to furnace, hereinafter referred to, and the horse droppings separated therefrom. This latter material, would, I am of opinion, find a sale as a dressing for grass lands, but if not sold it could be burnt.

The flint and gravel road sweepings are composed of small particles of flint, with horse droppings mixed with water, and could, with added water, be passed through a screen of a mesh gauged to pass the flint grit and retain the horse droppings. After drawing off the water the flint settlings would remain and be very valuable for consolidating the macadam roads under the steam roller. With this binding material a road is better made than if sand is used, and does not give off so much slop. Every yard of this material used would represent a saving of 4*s.* 6*d.*, and if such material was rewashed and passed through a finer screen the pure grit would fetch 10*s.* a yard.

The sweepings from wood-paved roads consist almost entirely of horse droppings, which could be sold as manure. The sweepings from Brompton Road, the committee are aware, now fetch £5 per barge load.

In the street refuse, the committee will therefore perceive that they possess valuable useful materials which they are now paying to get rid of, owing to want of storage space. Samples of all the component parts of the street refuse, as herein referred to, are herewith submitted.

The dust and house refuse is composed of breeze, dust, hard and soft core, and pickings, all possessing a market value, except the soft core, which would be burnt—a portion of the breeze forming the fuel.

The market for Kensington dust without doubt has, in the past, been spoiled by the inability of the vestry to hold over their stock, and the price for the same would go up on its being stored, and sold at such a rate as to make its own market. True it is that dust will be wanted as long as bricks are being made in the neighborhood, but so long as the vestry is without storage accommodation, the committee is at the mercy of the brickmakers, who have only to combine to dictate their own terms; but given the storage space, with the means of burning the soft core, etc., and the

positions are reversed, with the additional advantage of saving the labor now expended in carting the material long distances, a large part of it being not only of no use when it reaches its destination, but the cause of nuisances, which at any moment may place the vestry in the dilemma of having to collect the dust without having any place to shoot it.

The committee will perceive that the foregoing remarks all point to the desirability of the vestry acquiring depots within the parish for the receipt of the street and house refuse, and in addition to the direct saving resulting therefrom, as hereinbefore alluded to, I would point out other attendant advantages.

1st. The horses and men could be better supervised then when going to distant shoots, such as Acton, Fulham, etc., and the strictness of the supervision is inversely proportionate to the area of the work. There can be little doubt that a large proportion of the sickness and mortality amongst the vestry's horses is attributed to the distant shoots.

2d. A stock work would be provided for otherwise idle horses and men, whose unearned wages have now to be paid.

3d. The present shoots, costing a large sum for attendant men, chain horses, and road making, are only temporary; they are situated almost entirely in Fullam and Hammersmith, the board of works for which districts are just commencing the execution of their own work, and it is extremely unlikely that Kensington will be able, in the face of the extra carting involved, to offer better terms than Fulham for shoots within its own district, but outside ours.

4th. I would ask the committee to consider the equity of the question, whether it is fair for Kensington to send its offensive refuse into other districts, the authorities of which object to its presence, but perhaps are unwilling to take legal measures to stop its delivery. Acton, however, it will be remembered, did stop the delivery of our dust last summer.

5th. The neighborhoods now receiving the parish refuse are rapidly being built over, and in a short time will cease to afford shoots.

6th. The present distant shoots involve a large increase in the number of horses and carts, and proportionate increase in risks of working and increased cost of supervision. By having the shoots near the work a much smaller plant would do more work with greater efficiency, with the risks attendant upon bad roads, public water troughs, and unsupervised carmen, reduced to a minimum. Recently as many as 50 horses out of a stock of 84 have been employed in dusting alone, and that at a time when the slopping required extra strength, the lack of which entailed loss to the parish.

7th. The proximity of the depots would enable the horses to change carts quickly, a matter of much importance in the watering season, when through change of weather the horses have to be transfered from slop carts to water vans as expeditiously as possible. By the courtesy of the guardians of the poor we are allowed at present to stand carts, etc., at the stoneyard, potteries, a convenience liable, however, to be withdrawn at any time.

8th. By withdrawing a large number of carts, vans, etc., from the Pembroke Road depot, storage space would be given there, now much needed. At the present time, for want of room, I am often compelled to send material (other than street sweepings) to the shoot, which, if stored at the depot, could hereafter be used with economical results.

Each of the foregoing considerations are submitted in a condensed form only, but they are capable of being enlarged upon to a very considerable extent.

I beg, therefore, to strongly recommend that two depots be obtained; one in the north, and the other in the south part of the parish. In the northern depot pits could be excavated for the receipt of all refuse not sold, burnt, or utilized; the excavated clay being burnt into ballast worth *2s. 6d.* per yard in the depot. Such material will be largely required in the north district during the next 10 years, and its value will increase beyond the price named, proportionately to the difficulty in obtaining it.

In the south district the depot would yield sand and gravel, worth respectively, at present 2*s.* 6*d.* and 2*s.* per yard on the ground, but these prices are going up every year.

As before mentioned, the only portion of the street refuse for which, at the present time, I am unable to show a profitable use, is the fine mud of the granite slope, remaining after the granite and horse droppings are removed. This mud, although consisting of minute particles of granite, would, as far as I am able to see at present, have to be buried; dealing with it, however, in this way, the ground excavated for its reception would if sand more than pay for the labor involved, and nearly so in the case of clay having to be got out, such material being converted into burnt ballast as aforesaid.

A furnace would have to be erected at each depot, with sifting and screening apparatus, and the ground, if sufficiently spacious, could be so laid out in inclines as to make a good deal of labor self-performed by gravitation. Disinfecting chambers might be economically erected in conjunction with the furnace, and the money now paid by the vestry for the disinfection of clothing, bedding, etc., saved.

I would here remark that several large towns—Manchester, Birmingham, Warrington, Blackburn, Derby, Leeds, Nottingham, and Rochdale amongst others—have acquired depots and erected furnaces for dealing with and burning their refuse, and it is well worthy of the vestry whether a small committee might not be appointed with advantage to this parish to inspect the operations as carried out in the towns referred to.

If the committee and vestry agree with me as to the advisability of acquiring depots as herein suggested, I would recommend that no time be lost, as land is daily increasing in value and becoming more difficult to obtain. In addition, I would advise that ample space be provided, as the work is increasing every year, and would, even at the outset, require a large area for sorting and turning over the refuse, and the excavations as filled in as before mentioned would not renew their virgin soil.

In the foregoing report I have endeavored not to exaggerate the expected future results, but rather to take the worst view of the question, for I am firmly of opinion that the committee would find, after a year's experience in dealing with the refuse of the parish, that a great deal of so-called refuse, now costing a large sum annually to get rid of, would, under skillful management, prove a large item of revenue.

According to the less sanguine view of the subject, the vestry can afford to spend £60,000 on the acquisition of suitable land for depots, and the erection of buildings, machinery, etc., and still save on the present annual expenditure; but looking to the future, with the increasing difficulties of the work, I should be afraid to state the sum which the vestry might, in my judgment, spend with advantage for this purpose.

In the foregoing paragraph £60,000 is mentioned as the sum which might be expended without increasing the current expenditure, but it is not intended to convey to the committee that that amount of outlay is needed—£35,000 would, I am of opinion, cover the entire expense.

I trust I am not out of order in stating that should the vestry deem me over confident as to the profits likely to accrue from dealing with the refuse in the manner herein suggested, I believe private individuals are ready to come forward and enter into arrangements with the vestry, whereby you might be relived of all trouble with regard to such refuse when once deposited.

In conclusion, I would remark that in the foregoing report I have confined myself to the scope of the vestry's reference, but should it be deemed desirable, I could now, with the experience of the past 3 years' execution of the parish work, founded upon my report of 1876, offer some suggestions relative thereto, which, I believe, would prove of value to the vestry; but inasmuch as such reports involve considerable time and labor, I have thought it right not to withdraw the necessary time from my other duties without the vestry directing me to do so.

I have the honor to remain, gentlemen, your obedient servant,

WM. WEAVER, C.E.,
Surveyor.

STREETS OF LONDON.

Mr. Heward, surveyor, to Consul-General New.

BOARD OF WORKS FOR THE GREENWICH DISTRICT,
141 *Greenwich Road, Greenwich, S. E., January* 1, 1891.

SIR: In answer to yours of the 8th ultimo respecting the cost of making and maintaining public roads in London, I take pleasure in sending the following answers to your questions, obtained from practical results extending over a period of nearly half a century:

(1) The methods employed under my superintendence are: (*a*) Land value on flint roads; (*b*) Macadamized or broken-granite roads; (*c*) granite-cube or set paving; (*d*) wood-cube paving; (*e*) asphalt.

I attach a specification, marked A, giving details for forming and making up new roads or streets, on which system land values or macadamized roads are constructed in my district, also a specification, marked B, giving details of forming granite-cube and wood-cube paving. Asphalt, although the more costly material at first cost, is the most cleanly and durable of any, but is not easily repaired after trenches made by gas, water, electric, and other companies, and is very treacherous under certain conditions of atmospheric changes for horse traffic. The foundation for an asphalt is made as for a paved road, with a 3-inch coating of asphalt in lieu of the granite cubes.

(2) Systems followed in repairing roads (*a* and *b*) by picking up the crust or surface to a depth of about 2 inches and coating same with material to a depth of about 2 to 3 inches, and the whole rolled solid, cost (*a*) about 1*s*. per yard superficial; (*b*) from 2*s*. to 3*s*. per yard superficial. The life of these roads depends entirely upon traffic and weather, but an average of 2 years might be taken.

The life of a granite-cube paved road is about 21 years, with an average expense for repairs of 6*d*. per yard superficial per annum.

The life of wood-cube paving is from 4 to 5 years, and the average expense per annum would not exceed 6*d*. per yard superficial.

Asphalt will stand from 15 to 20 years if left undisturbed.

(3) The effect of improved public roads upon land values depends entirely upon situation and traffic. Where heavy traffic has to be carried, and in large towns and cities, improved paving is found more economical and cleanly, but land values or macadamized roads are less costly and preferable in country or park roads, where traffic is of a lighter nature.

I trust this information is what you seek, but shall be pleased to answer any further questions you may wish, upon your application.

I have a book, "System of Road-Making," by John Loudon MacAdam, 1827, which I should be pleased to lend for your perusal. I can not part with same, as it was given to me by my tutor, Sir James MacAdam.

Yours, respectfully,

JAMES R. HEWARD,
Road Surveyor to the Greenwich District Board of Works.

JOHN C. NEW, Esq.,
Consulate-General of the United States of America, London, E. C.

A.

BOARD OF WORKS FOR THE GREENWICH DISTRICT.

Specification for forming and making up the roadway and paving, curbing, channeling, and making up the footpaths of the street called America, in the parish of ——, in the Greenwich district.

The contractor is to remove all slop, mud, clay, and soft material in proper slop carts when and as required by the road surveyor to the board of works for the Greenwich district for the time being, and to remove and cart away all superfluous earth and regulate the finished level of the roadway by the general level of the adjoining premises, as determined by the said surveyor.

The surface of the roadway to be properly formed by the contractor previously to the whole width of such roadway being covered by him with a good 9-inch dressing of hard pottery or brick waste, to be evenly spread and well rolled by him, after which he is to lay on such road a good 6-inch coating of Guernsey granite in two 3 inch dressings, and to well and evenly break, spread, water, and roll in the same with 10 tons.

The footpaths on both sides of the above road are to be paved with best 3-inch tooled York stone. (The width of footways can be stated.)

The contractor is to provide and fix on edge, on both sides of the above-mentioned road, a good 7 by 12 inch granite curb, squared at both ends, with close-butting joints, well jointed and parallel on the top, with circular and return curb for all the corners, gateways, and approaches, where required by the said surveyor, and to pave the channels with 5-inch by 6-inch and 6 inches deep approved granite cubes on both sides of the said street, to be set on best concrete 6 inches deep, three stones wide, and to pave the same to a proper gradient for the gulleys, to well grout the same with hot lime and sand, and well ram down the same.

The crossings, to be of best dressed granite, are to be paved by the contractor with 7-inch by 4-inch and 7 inches deep, to be laid on concrete 6 inches thick, to be well and properly rammed and grouted in with Shay sand and hot lime.

Any private gateways are to be paved by the contractor with 3-inch by 6-inch and 6 inches deep dressed granite cubes set on 4-inch concrete, to be well grouted in with hot lime and properly rammed.

The contractor is to shift and remove such of the present gullies as the said surveyor may direct, so as to range with the paved channels.

The contractor shall construct ——— gullies, in such places as may be pointed out by the road surveyor, with No. 1 best wire-cut Galt bricks, well bonded, 9 inches in thickness, in Portland cement, with invert bottom, the whole surrounded with Portland cement concrete 6 inches in thickness, the entire inner faces of the gullies to be rendered with Portland cement three-fourths of an inch in thickness, to connect the said gullies with the sewers, with best 6-inch (in the bore) glazed stoneware pipes jointed with clay; also to provide and fix a cast-iron grating and frame and cast-iron siphon trap (as per plan) to each gully, sample to be seen at the office of the board. The contractor must, previous to the commencement of the construction of any gully, give two days' notice to Mr. J. Nidd Smith, the district board's engineer, under whom and to whose entire satisfaction the work is to be performed.

All watching, lighting, fencing, and notices for gas and water companies and others which may be necessary shall be provided and given by the contractor, who will be held responsible for any accident or damage of whasoever description that may happen or occur during the progress or execution of or in completing the works referred to in this specification.

If, under the direction in writing of the said surveyor, the contractor omits to do any of the before mentioned works, or to supply any of the before-mentioned materials, or does any additional work, or supplies any additional materials, then such omissions or additions shall be valued by the said surveyor, and the amount of said valuation deducted from or added to (as the case may be) the sum at which the contractor shall tender to execute the said works.

All the said works are to be executed and completed under the direction of the said surveyor, and to his entire satisfaction; and if any question should arise as to the labor or material, the levels, or the mode of executing the said works, or otherwise in reference to this specification, or with regard to any extras or omissions (if any), all such questions shall be finally determined by the said surveyor.

Advances of money at the rate of 75 per cent. on the value of the work executed, as certified by the said surveyor, will be made to the contractor as the works proceed until the whole of the works are completed, but such advances shall in no case be made at more frequent intervals than monthly, or until work of the value of £100, certified as aforesaid, shall have been completed, and such certificate shall be final and binding for the purpose of determining the amount of the advances to be from time to time made under this clause, but shall not affect the right of the board against the contractor, or be considered or be held at all conclusive as to the sufficiency of any work or materials; and such advances shall in no way affect any question in the ultimate settlement of the accounts, or be considered as proof or admission of any particular work, or amount of work, having been completed; and the balance shall be paid at the expiration of 3 months from the time when the work shall have been completed in accordance with the contract, and the said surveyor shall have certified in writing to the board that the works have been so completed to his satisfaction.

The commencement of the works referred to in this specification is to be postponed until the time for commencing the same shall be specified in a written notice, given to the contractor by the said surveyor, and the contractor shall commence the same at the time specified in such notice, and must execute and complete the whole of the said works within 3 calendar months after the time so specified for commencing them, and if the said works are not completed within the said period of 3 calendar months, the contractor shall pay to the said board the sum of 20s. for every day until the works are completed to the satisfaction of the said surveyor; and all such sums payable under this clause, and any expense which may be incurred by the board by reason of delay on the part of the contractor, shall be deducted from the amount payable to him under this contract, or paid by him to the board on demand.

The contractor must execute, when required, a written contract in due form, to perform, fulfill, and complete the works mentioned and referred to in the above specification, and in all respects according to the terms thereof.

J. R. H.,
Road Surveyor to the Greenwich District Board of Works.

B.

PARISH OF GREENWICH—NEW GRANITE AND WOOD PAVING WORKS.

BOARD OF WORKS FOR THE GREENWICH DISTRICT,
June 23, 1886.

Specification to pave the unpaved portions of the Greenwich road, from Wellington Grove to London street, of London street, from Greenwich road to Royal Hill, of Romney road, of Trafalgar road, and of the lower Woolwich road (except in front of Christ Church and the Wesleyan Chapel) from Trafalgar road to Marsh Lane, in the parish of Greenwich, with 7-inch by 3-inch, or 7-inch by 4-inch granite cubes, and to perform other works in connection therewith; and to pave the unpaved portions of London street from Royal Hill to Stockwell street; of Church street, from Stockwell street to Nelson street, and of Nelson street, and in front of Christ Church, and the Wesleyan Chapel in the lower Woolwich road, in the parish of Greenwich, with 6-inch by 3 inch wooden blocks, and to perform other works in connection therewith.

1. The contractor shall remove all the macadam or paving belonging to the board, forming the surface of the road between the curb and existing granite paving outside the tram rails to a formation level, and cart the macadam, paving, cubes, curb, or other stone to the board's wharf, or any other depot at a distance of not exceeding 2 miles from any part of the works.

2. The contractor shall dress the surface level at the foundation to the same profile as the paved surface will have when completed, and provide and lay thereupon and over the entire area thereof, a bed of concrete, 6 inches in depth.

3. The concrete for the granite paving is to be formed of the best fresh burnt ground blue Rugby, blue lias, or other approved hydraulic lime, clean sharp Thames or approved ballast, in the proportion, by measurement, of one part lime to four of ballast, to be laid in place and fretted to the required level at once, and, if required, to be well punned with iron rammers, and left undisturbed until the same is set and the granite sets are laid upon it.

4. The concrete for the wood paving is to be composed of best Portland cement, weighing not less than 116 pounds to the strike bushel, and is to bear a breaking weight of 410 pounds to the square inch, is to be mixed with clean sharp Thames or approved ballast, in the proportion, by measurement, of one part cement to four of ballast, to be laid in place, and fretted to the required level at once, and, if required, is to be floated to an even surface, and left undisturbed, until it is set and the wood blocks are laid upon it.

5. The contractor is to provide, deliver, and lay on a bed of clean sharp gravel mixed with blue Rugby, blue lias or other approved lime in the proportion of one of lime to four of gravel, on the concrete bed and parallel to the lines of curb, two courses of approved granite sets, 7 inches in depth and 4 inches in width, or 7 inches in depth and 3 inches in width, as may be directed, to form a channel where directed.

6. The contractor is to provide, deliver, and lay on a bed of clean, sharp gravel, mixed with blue Rugby, blue lias, dry, or other approved lime in the proportion of one of lime to four of gravel on the concrete bed, and between the existing paving outside the tram rails and the channel stones by the curb hereinafter described, approved granite sets 7 inches in depth and 4 inches in width, or 7 inches in depth and 3 inches in width, as may be directed, such sets to be properly bonded in with such existing paving.

7. The pitchings or sets are to be of the best and hardest description, each stone is to be 7 inches deep, and 3 or 4 inches in width, as may be directed, to be perfectly square on all sides, the bottom full and equal to the top, and before being used shall have the special approval of the surveyor. The top and bottom are to be roughed not hogbacked, and the stones are to be laid in regular courses, straight, parallel, and of an equal width and (except the channel courses specified above) at right angles with the curb, unless otherwise directed, and to be rammed and back rammed after the grouting as often as may be required by the said surveyor.

8. The wood paving to be of the best sound and approved pitch pine blocks, free from sap or knot, 6 inches deep, 3 inches in width by 9 inches, set as directed on a bed of clean sharp sand, mixed with Portland cement in proportion by measures of one of cement to four of sharp sand set at right angles with the curb, unless otherwise directed, and to be rammed and back rammed after the grouting as often as may be required by the said surveyor.

9. The grout to be formed of the best burnt ground blue Rugby, blue lias, or other approved hydraulic lime, and best clean sharp Thames or other approved sand of an equal quality in proportion by admeasurement of one of lime to three of sand; it is to be well worked up and amalgamated and spread upon the paved roadway and well worked into the joints and interstices with scrapers and brooms so as to run into and through and fill up all the joints and interstices, and afterwards is to be dressed over with washed and screened granite or gravel as often as may be considered necessary by the surveyor for 14 days after the road is open for traffic.

10. The contractor is to keep and maintain at his own cost and charges, in good and substantial repair, free from looseness, sinkings, holes, indents, wide joints, and all other imperfections, the whole of the works herein specified for one year after the date of the said surveyor's certificate that the whole of the works have been completed to his satisfaction.

11. In case any company or person shall at any time during the said twelve months open the roads or any part thereof, the work of relaying the granite and reinstating or repairing the road so broken up, shall be executed by the contractor, and the amount received by the board from such company or person for restoring the road shall be paid to the contractor.

12. From the date of the contract until the completion of the works, the board will water, scrape, sweep, and cart away the road scrapings and sweepings of such part of the roads as shall be open for the public traffic, in such manner as the board may think fit.

13. The contractor shall commence the works within three weeks after he shall have received a written order to do so from the surveyor, and complete the works and deliver up the same to the said board, within 16 weeks after the receipt of the said order, under a penalty of £25 sterling per day, for each and every day that the same shall remain incomplete after the expiration of the said 16 weeks, and in case of such default, the amount of any penalty or penalties so incurred is to be deducted from any moneys due to the contractor, or recovered from him as liquidated damages.

14. The contractor shall not have or put forward any claim for any sum or balance of money whatsoever, as due to him from the board, except on the certificate of the surveyor.

15. That payment shall be made to the contractor for the works herein specified in manner following: 75 per cent. of the estimated value of the works executed on the certificates of the surveyor, such certificates to be granted at the expiration of every 4 weeks after the commencement of the works. Such further sum as shall make the total payments amount to 90 per cent. of the contract sum, with the amount of extra works (if any) added thereto, or if omissions, deducted therefrom, within 28 days after the date of the certificate of completion of the whole of the works to the satisfaction of the surveyor. A further payment of 5 per cent. thereon within 3 months after the said completion, and the balance within 12 months after the completion.

16. Should the works, in the opinion of the surveyor, not be carried on with sufficient despatch, or should the contractor neglect or refuse to amend any works or materials objected to by the surveyor, then it shall be competent for him, the said surveyor, after giving to the contractor 48 hours' notice of his intentions so to do, to employ other persons, or procure other materials, so as to perform and amend the said works, and all costs so incurred are to be deducted out of any moneys that may be due to the contractor in respect of the contract or extras thereon, or may be recovered as a debt, at the option of the board.

17. If any dispute shall arise between the contractor and the board, or between the contractor and the surveyor, as to meaning or intentions of this specification and tender, such matter shall be referred to and explained by the surveyor, whose explanation and award shall be final and binding upon the contractor and the board.

18. The contractor shall not be entitled to make any claim against the board for any works whatever, in addition to those herein tendered for, except such additional works shall have been performed, executed, and completed upon a written order, signed by the surveyor.

19. If the contractor should from bankruptcy, insolvency, or any other cause whatever be prevented or delayed in proceeding with the work, or be unable to proceed with the work, according to the contract, or shall not proceed therein to the entire satisfaction of the surveyor, it shall be lawful for the board, after seven days' previous notice to the contractor herein stated, of their intention so to do, to enter upon the works, and take possession of them, and of all materials and plant that may be on the works, and to employ other persons to complete the works, and at the option of the board the contract shall, at the expiration of the said notice, become void to the contractor, but without prejudice to any right of action the board may have. The contractor in such case shall have no further claim for such works, materials, or plant, but such payment as may have been previously made shall be considered and taken as payment in full for all such materials or plant, or work done.

20. In case of the death of the contractor before the works hereby undertaken by

him shall have been executed, performed, or completed, his executors or administrators shall execute, perform, and complete the same.

21. The contractor shall not underlet or make a subcontract for the execution of any portions of the works, nor assign or otherwise dispose of, or part with his interest in the contract, or any part thereof, without the previous consent in writing of the board.

22. The contractor or contractors shall securely and properly fence off and light the works during the progress thereof in such places and at such times as may be necessary for the safety of the public, or as the surveyor may direct, and whether the surveyor shall give directions or not the contractor is to be held responsible for any accident that may occur through noncompliance with or neglect of this clause. The contractor is to be held responsible for and to make good any damage to gas or water pipes, drains, fences, or other works or property damaged by him during the progress of the works, or which may occur in consequence of the works within 4 months after the completion, and in case of default on the part of the contractor the damage will be made good by the surveyor, and the amount thereof deducted from any money due, or which may become due to the contractor, or may be recovered from the contractor in an action.

23. The contractor shall include in his estimate the sum of 2 pounds 10 shillings per week to be paid by the board to their clerk of the works for superintending the works herein specified during the period of their execution, and the sum so paid to such clerk of the works shall be deducted from the amount of the contract after its final completion.

24. All the materials and workmanship of their several kinds are to be of the best description, and are to be approved by the surveyor.

25. In this tender and contract the word "contractor" shall include his heirs, executors, or administrators." "The board" shall mean the board of works for the Greenwich district. The "surveyor" shall mean the road surveyor of the board for the time being, or any other surveyor from time to time appointed by the board in respect of this contract.

26. Every notice shall be deemed to be served upon the contractor which shall have been put into the post addressed to the contractor at his address hereunder stated, or to any other address which he may furnish in writing to the clerk of the board.

BOARD OF WORKS FOR THE GREENWICH DISTRICT,

Parish of Greenwich:

—— hereby tender to and agree to perform and keep in repair for 12 calendar months, all the works in the foregoing specification, and to perform all the conditions thereof at the price hereunder stated per superficial yard of road surface, broken up and paved with new granite or wood cubes in manner hereinbefore mentioned.

	s.	d.
Price per yard superficial if the paving is executed in—		
7 × 3 Mount Sorrel granite	15	0
7 × 4 Mount Sorrel granite	13	0
7 × 3 Guernsey granite	15	0
7 × 4 Guernsey granite	14	0
7 × 3 Aberdeen granite	14	0
7 × 4 Aberdeen granite	13	0
Price per yard superficial for wood paving 6 × 3 × 9 pitch pine	10	6

And —— further agree to relay the existing paving outside the tram lines where required by the surveyor to do so, at the price of ——— per superficial yard.

And —— agree to execute a contract for the performance of the works, as aforesaid, upon being requested to do so.

(*Name of person tendering:*) ——— ———,

(*Address:*) ——— ———.

Tenders must be delivered at the board's office, 141, Greenwich road, not later than 4 o'clock on Wednesday, 23d June, 1886.

Schedule of Prices.

Parties tendering are required also to fill in prices for additional works as per following schedule:

	s.	d.
To supply and fix new 12 × 7 Aberdeen edge curbs, at per foot run extra....	1	10
To supply and fix new 12 × 6 Aberdeen edge curbs, at per foot run extra....	1	8
To supply and fix new 12 × 8 Guernsey channel curbs, at per foot run extra.	2	2
To take up existing curbs and reset same, at per yard run..................		2
To take up, redressing, and resetting curbs, at per yard run		6
To supply and lay complete best 3-inch Yorkshire flaggings, at per foot superficial		10½
To supply and lay complete best 2½-inch Yorkshire flaggings, at per foot superficial		9½
To remove and relay old York, to square and relay same at per 100 feet.....	10	6
To relay old channel, carriageway cubes and grout same complete, at per yard superficial........	1	2
To supply and lay down on a bed of Portland cement concrete, 6 inches in thickness, the concrete to be composed of one part Portland cement to four of clean Thames ballast, approved pitch pine blocks, 6 by 3 by 9 inch, of the best quality, free from sap or knots, at per yard superficial...........		
To supply and lay down on a bed of Portland cement concrete, 7 inches deep and 3 inches in width, at per yard superficial........		
To take up, redress if necessary, and relay on any portion of the works, any old cubing as directed, at per yard superficial........		
To supply and lay concrete as described in clause 3 of specification at per yard cube		

All digging and carting in any way connected with, preparing for, or in the execution of the works herein referred to, shall be included in the above prices.

REPORTS OF MR. HAYWOOD.

The following four inclosures in Consul-General New's report are reports of Mr. Haywood, engineer and surveyor to the commissioners of sewers of the city of London.

ACCIDENTS TO HORSES ON CARRIAGEWAY PAVEMENTS.

SEWERS OFFICE,
GUILDHALL, *December* 16, 1873.

To the HONORABLE THE COMMISSIONERS OF SEWERS OF THE CITY OF LONDON:

GENTLEMEN: The following is the reference made to me:

"That the engineer cause observations to be made and particulars taken as to the number of accidents befalling horses on the asphalt, wood, and granite pavings, under as nearly as possible similar circumstances, distinguishing the different results under various conditions of weather, and showing the percentage of accidents under each circumstance and condition; also taking note of any other particular he may think desirable, with a view to elicit the greatest possible amount of information respecting the various pavements."

After considering the means to be taken for obtaining the desired information with the least delay and expense, I came to the conclusion that the police could be usefully employed for the purpose; accordingly I applied to Colonel Fraser, who expressed his

willingness to assist the commission by allowing a certain portion of the police force to take the daily observations, and arrangements were ultimately made with him to this end.

Books were then prepared by me in such manner as appeared best suited to insure accuracy in recording the traffic and accidents, as well as to reduce the labor of the work. These books when filled up by the police, were placed in the hands of my assistants, who checked the casts, and arranged the figures so as to enable me to prepare the summaries and tables which are herewith submitted.

Forty-three men were employed altogether in taking the observations of traffic and accidents, 38 of whom were constables. The constables acted under the inspection of 4 sergeants, and their duty was so arranged that inspection was never taken off them. The whole service was directed and superintended by the chief inspector of police.

The observations taken were:

Firstly, of the traffic: The number of horses and vehicles which passed through the selected streets.

Secondly, of the accidents which occurred to the horses.

I. *Traffic.*—For ascertaining the traffic 2 men were stationed at each point of observation, and on opposite sides of the way, each man taking the traffic on the side of the road which was nearer to him, and passing in one direction only. The men were employed for 3 hours at a time, and were then relieved by others for 3 hours; and there were, therefore, altogether 4 men employed during the day at each point of observation. Each man was on duty for 6 hours daily. The observations were taken from 8 a. m. to 8 p. m., a period of 12 consecutive hours.

Observations of the main streams of traffic were taken at each selected spot for 2 consecutive days in a week; and were followed by 2 other days' observations in the week after, but on different days to those of the preceding week. They were carried on in such order until 6 days' observations, including every day in the week (Sundays excepted) had been taken at each point. Observations of cross or collateral traffic were also taken sufficiently to enable the effect on the general stream of traffic to be ascertained.

Whilst the traffic was being taken none of the streets in the vicinity of the main thoroughfares under observation were materially obstructed for paving or other works and the traffic was therefore in its normal state.

II. *Accidents.*—The number of men employed in taking account of the accidents was 30, 15 being on at a time. The relief took place every 3 hours, and the men were subject to the same supervision by the inspectors and chief superintendent as those taking the traffic.

The observers were stationed at such points as enabled each man to see easily the area assigned to him without moving far from a central position. These points had been fixed after careful observation by myself, so as to ascertain the area which could be properly watched. Each man recorded all the accidents which occurred on his assigned area.

Owing to differences in the extent and nature of the traffic, the width of streets, and other conditions, the length of thoroughfare assigned to the men varied from 239 feet to 636 feet, and the areas from 640 to 2,071 yards superficial; the mean of the whole being one man to every 333 feet lineal and 1,226 yards superficial of carriage-way pavement. These lengths and areas are shown on the plan accompanying this report, and also in Table A in the appendix.

The observations of accidents were commenced on the 10th March last, and continued until the 5th April, during which time the weather was generally fine. As there was no appearance of change in the weather, and it being in the highest degree desirable to have observations during all kinds of weather, they were then discontinued. On the 9th May, as rainy weather appeared likely to ensue, they were resumed, and continued until the 7th June. The weather, however, became again fine, and continued for the most part so until the observations were completed. They were discontinued because police arrangements did not admit of their being prolonged.

As the horse traffic in the city is much less on Sundays, being in fact in the main streets only from 20 to 30 per cent. of that which passes on other days in the week, the observations were confined to working days alone.

By omitting Sundays there were 50 working days on which observations of the accidents were made.

As the expense would have been largely increased by taking observations during the night; as owing to the darkness they would have been less reliable; and as the great bulk of the traffic passes through the city thoroughfares between 8 a. m. and 8 p. m., observations of accidents were made only during those 12 hours of day.

During the first three weeks the accidents were recorded without explanation of their nature; but as a large proportion of the horses were observed to fall only on their knees, the accidents on the remaining 32 days were classified under the heads of "falls on knees," "falls on haunches," and "complete falls." No notice was taken of the mere slipping of a horse.

The weather during the observations will now be generally described, for, whatever be its character, weather affects the surface of all pavements and largely influences the conditions under which slipperiness varies.

The direction of the wind varied during the 50 days, but was principally either from the north, east, or northeast. The prevailing direction was northeast.

The mean temperature of the 24 hours, as taken from the registrar-general's returns during the period, varied from 34.5° to 60.9°. The observations of temperature taken in Guildhall yard by me daily, at 9 a. m. and 3 p. m., show a variation of from 35.7° to 64.8°. The mean daily temperature was for the most part somewhat below the average.

Out of the 50 days there were but 17 days on which rain fell. On the average there are 150 days annually in London in which rain falls at some period during the 24 hours; therefore, during the 50 days' observations there was proportionately less than the usual number. I find also there was a less number of rainy days than the average during those particular months, and that the quantity of rain was far less than usual. This is a fact much to be regretted, inasmuch as the slipperiness of all pavements is very much affected by moisture, although in different manners and in different degrees. The character of the weather will be further dealt with in another portion of the report.

The reference to me being to take observations of the accidents befalling horses on asphalt, granite, and wood, and there being a variety of each of these classes of pavement on each of which the slipperiness varies, it became necessary in the first place to determine which to select, and I ultimately chose one of the compressed asphalt of the Val de Travers Company, and one formed of 3-inch Aberdeen granite cubes, these two kinds being the best known and the most extensively used in London of their several classes. I also selected the improved wood pavement, this being the only one of which there was any large quantity laid down in the city, and a specimen of the ligno-mineral pavement which lay adjacent to it.

It would have been desirable to have had observations taken in streets of similar width and gradient, of which the pavements were in equally good condition of repair, and the traffic passing over them as nearly as possible the same in character and extent, as comparisons would then have been more easily made, and discrepancies more readily accounted for. This similarity in conditions was unattainable; and after giving the subject much consideration, I selected Cheapside and the Poultry, King William street, part of Gracechurch street, and the eastern portion of Cannon street, of which the surface conditions generally were:

Asphalt.—Cheapside and the Poultry were paved with the compressed asphalt of the Val de Travers Company, laid 2½ inches thick, on a bed of concrete 9 inches thick. The surface of this pavement was in good condition.

The total length of these two thoroughfares was 2,033 feet, and the area of the carriageway 6,914 yards superficial. The worst gradient was on a length of 48 feet

next to St. Paul's churchyard, which was 1 in 58. The other gradients varied from 1 in 66 to 1 in 550, nearly the whole length of the two thoroughfares being less steep than 1 in 70.

The traffic in Cheapside and the Poultry was of a mixed character, including a considerable number of omnibuses. It was for the most part slow, especially in the Poultry.

Granite.—King William street from Cannon street to Lombard street, and Cannon street from King William street to Walbrook, were paved with Aberdeen granite. The stones were 3 inches wide, 9 inches deep, and from 9 to 15 inches long, laid so as to touch each other, the joints being filled in with stone lime grout. The pavement of Cannon street was a little out of repair; that of King William street in a bad state of repair. The latter was under order to be replaced by a new pavement, which has since been laid.

The pavement in King William street was 675 feet long, and had an area of 2,379 yards. A length of 138 feet at its northern end had a gradient of 1 in 54; the remainder was from 1 in 68 to 1 in 1,000.

The traffic in this part of King William street was much the same in character as that in Cheapside and the Poultry, but on the average it passed through it at a greater speed than in the other thoroughfares under observation.

The portion of Cannon street under observation was 807 feet long, and its carriageway had an area of 2,752 yards. A length of 326 feet at the western end had gradients of 1 in 30 and 1 in 31. The remainder varied from 1 in 61 to 1 in 841.

The traffic in Cannon street was generally slow, a large number of one-horse vehicles passing through it, and only a few omnibuses. Carts stopped for loading and unloading in front of the premises on the southern side of the street during the largest portion of the day.

Wood.—The wood pavements under observation were two in number; that of the Improved Wood Paving Company, and that of the Ligno-Mineral Paving Company Trenaunay's patent).

King William street from London Bridge to the Statue, and a small portion of Gracechurch street, were paved with the improved wood pavement, which is formed of fir blocks 3 inches wide, 5 inches deep, and 9 inches long. The blocks are laid touching each other at their ends, but crosswise of the street, the joints are three-quarters inch wide, filled in with fine clean gravel, and then grouted with a bituminous composition. The total length of this pavement was 1,394 feet, its area 5,937 yards. Its surface was in excellent condition.

A length of 130 feet of this pavement near to Crooked Lane had a gradient of 1 in 30. Near to Eastcheap was a length of 83 feet with a gradient of 1 in 34. The remainder varied from 1 in 37 to 1 in 260. Near to the statue of King William IV the pavement had also in several places a steep transverse slope.

The pavement in Gracechurch street of the Ligno-Mineral Paving Company consisted of beech blocks, 3½ inches wide, 6 inches long, and 4½ inches deep, laid with longitudinal and transverse joints one-quarter inch wide. The wood was mineralized, and the joints were filled in with cement or lime grout. It was laid on a bed of concrete 5 inches thick. The surface was in good condition.

The length of the ligno-mineral pavement was 87 feet, the area 410 yards, and the gradient 1 in 49.

The traffic over the wood pavements in King William street and Gracechurch street comprised vehicles of all descriptions, and in King William street included very much of that which passed through the other thoroughfares under observation. The traffic passed generally at a slow rate, but from Arthur street to London Bridge during two or three hours of the day it was less slow in the center of the street.

It is necessary to make some further remarks in reference to these wood pavements. When I included for observation the two kinds described, I did so because it was desirable to observe considerable lengths of street. The pavements were adjacent to

each other, and could be conveniently watched from one station. It did not then occur to me that there was any material difference between the two in respect of safety; but as investigation into the causes of the accidents advanced and the various abstracts and tables were made up a very remarkable difference became apparent. I do not feel justified in leaving out the observations taken on the ligno-mineral pavement, and the accidents which occurred on it are accordingly included with those which occurred on the improved wood pavement, and they are given together in the totals and general results. If there had been no more than a trifling difference between them in the proportion of accidents I should take no notice of this difference, for looking at the mixed causes which lead to accidents it might not have been practicable to do so usefully; but the excess of falls on the ligno-mineral is so great as materially to alter the relative position of the wood to the other pavements as regards safety. Although, therefore, as before said, the general tables include the accidents on both, it has been necessary to separate them in various parts of the report to prevent erroneous conclusions being drawn.

The lengths and areas of the thoroughfares under observation will be found in Table B in the appendix.

All the pavements during the period of observation were cleansed every morning and were also cleansed constantly during the busiest hours of the day by street orderlies. The asphalt was occasionally, but not frequently, washed in the morning; and all the pavements were, therefore, as clean as the nature of their respective surfaces admitted with the amount of labor and expense which was ordinarily bestowed on them. No measures were taken to keep them cleaner than the other main thoroughfares in the city.

It was frequently noticed that accidents occurred on the asphalt when it was dry, owing to the horses putting their feet on fresh droppings; but scarcely any appear to have taken place from this cause either on the granite or the wood.

During the period of observation the asphalt was not watered to lay the dust, it not being customary to water that material, but the granite and wood were watered the same as other thoroughfares of the city.

Some of the accidents on the wood were undoubtedly attributable to the moisture caused by this surface watering, but accidents attributable to a similar cause do not appear to have taken place on the granite pavement.

The asphalt, when the surface was damp or slippery, was occasionally strewn with fine sand by the street orderlies, but this sand was used sparingly, and owing to the state of the weather the necessity for using it was small.

The improved wood pavement was on four occasions during the observations slightly strewn with fine gravel. This was done by the contractors to indurate the surface in the way customary with wood pavements. On only one of the four occasions was the pavement in such a state that strewing gravel was likely to be useful to prevent accidents.

Nothing was strewn either by the contractors or by the commission on the ligno-mineral pavement during the time it was under observation.

In the calculations, which are based on the extent of traffic, the mean traffic arrived at by observation has been taken to apply to the whole time during which the observations of accidents were made. It would, of course, have been more strictly correct to have made daily observations of the traffic throughout the whole period simultaneously with those made of the accidents; but to have made them would have largely increased the expense, and experience has shown that it is unnecessary to prolong such observations for the purpose of obtaining averages.

It is assumed in this report that each horse traversed the entire line under observation. Each line was carefully defined, measured, and separately calculated. For example, at the western end of Cheapside there were three streams of traffic, each stream having a different length of journey. On each of these the number of horses and the accidents occurring to them were separately recorded and the mileage trav-

eled by the horses ascertained. The same was the case near the statue in King William street, where there were various lines of traffic, all of which were dealt with in a similar manner. The collateral traffic was not taken for any length of time—to have done so would have much increased the expense—but it was taken at every cross street, so as to learn how the average number of horses passing through the main line was affected by it, and the variation in numbers was found to be, generally speaking, as much on the one side as on the other. As the observations on the main lines were all taken from points selected, so as to include the collateral traffic as far as practicable, it is believed that a very correct average of the whole has been obtained.

It has now to be stated that although the scope of the reference is wide, yet in writing this report I have thought it desirable to keep closely to the manifest object of the reference, which is, as I understand it, *to ascertain by direct observation the relative safety of the three classes of pavement.* I have therefore not referred to statements made from time to time to the commission, either by the owners or drivers of horses, the proprietors of pavements, the police, or the public as to the safety of particular pavements. Nor have I referred to previous observations or to other information already before the commission on the subject, but have dealt simply with the results of the observations specially made for this report.

I have also avoided entering on the advantages and disadvantages generally of the different kinds of pavements.* To have done so would have made this report an essay on pavements rather than a report on the accidents occurring on them. I have avoided as far as possible giving opinions of my own on the matter, though it has been essential to draw attention to those conditions under which the pavements differ from each other, and for which difference due allowance will have to be made in judging the results. Had I not done so the general results given in some of the tables might have been taken as applicable to similar pavements under all conditions and seasons, which would have been erroneous.

A plan is appended showing the pavements which were under observation, their nature and gradients, with the horse traffic which passed at certain places, and it contains other information explanatory of the report.

The most important of the abstracts by which the tables and summaries are arrived at, and from which the conclusions set forth in the report are drawn, are also appended. By reference to these abstracts the details of the observations will be seen. These abstracts are:

(A) Table showing length and superficial area of carriageway pavement observed from each station.

(B) Table showing the length and superficial areas of the thoroughfares in which the observations of traffic and accidents were taken.

(C) Table showing the number of horses and vehicles passing through various thoroughfares during 12 hours, from 8 a. m. to 8 p. m.

(D) Table showing the mean numbers of vehicles drawn by 1 horse, 2, and 3 or more horses that passed over the various pavements in 12 hours, from 8 a. m. to 8 p. m.

(E) Table showing the number of horses that fell on the various pavements between 8 a. m. and 8 p. m., the state of the weather, the direction of the wind, and other information during certain days in March, April, May, and June, 1873.

(F) Table showing the traffic, number of horses that fell, and the distance traveled before a horse fell on each of the various pavements.

(G) Table showing the proportions of horses that fell on knees, on haunches, and completely on the various pavements during 32 days' observations.

(H) Table showing the number of horses that fell in vehicles drawn by 1 horse, 2, and 3 or more horses.

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* These will be dealt with in a report upon the relative advantages of wood and asphalt, which I shall shortly commence.—W. H.

(I) Table showing the total number of horses that fell in vehicles drawn by 1 horse, 2, and 3 or more horses over the three descriptions of pavement.

(K) Table showing the distance traveled by horses in vehicles drawn by 1 horse, 2, and 3 or more horses, respectively, before a horse fell.

(L) Table showing the order of slipperiness as compared with the gradients upon each class of pavement.

Throughout the report the pavements are referred to in alphabetical order: Asphalt, granite, wood; this being a convenient mode to adopt for general reference, as well as for other reasons. They are transposed in some of the tables incorporated in the body of the report, where they have been arranged so as to show more clearly their relative safety.

Having now laid before the commission a general account of the nature of the observations taken and the manner in which they have been used, I proceed to state the general results.

TRAFFIC.

The horse traffic daily between 8 a. m. and 8 p. m. on the working days in the months of March and April, 1873, during which the observations were taken, are given in table C in the appendix; the mean traffic at the most important points on the lines was:

	Number of horses passing from 8 a. m. to 8 p. m.
Asphalt:	
Cheapside, east of Milk street	12,366
Poultry, by Grocers' Hall court	10,920
Granite:	
King William street, by Abchurch lane	8,555
Cannon street, by Bush lane	5,350
Wood:	
King William street, north of Arthur street	21,162
Gracechurch street, by Talbot court	11,484

The vehicular traffic was separated in the observations under the heads of one, two and three or more horse vehicles. The details of these observations are given in Table D in the appendix, but the mean number which passed at the most important points on the line is given in the following table:

Table showing the mean number of one, two, and three or more horse vehicles, respectively, passing through the streets under observation in March and April, 1873.

	Mean number of vehicles passing from 8 a. m. to 8 p. m.			Total.
	One horse.	Two horses.	Three or more horses	
Asphalt:				
Cheapside, east of Milk street	6,533	2,825	61	9,419
Poultry, by Grocers' Hall court	5,472	2,637	58	8,167
Granite:				
King William Street, by Abchurch lane	4,276	2,006	89	6,371
Cannon street, by Bush lane	4,090	585	30	4,705
Wood:				
King William street, north of Arthur street	10,273	4,831	409	15,513
Gracechurch street, by Talbot court	5,817	2,469	243	8,529

The proportions of the whole are as follows:

	Per cent.
Vehicles drawn by one horse	71.42
Vehicles drawn by two horses	26.95
Vehicles drawn by three horses	1.63

Some general idea of the character of the vehicles which passed along these thoroughfares, together with the proportion which the several classes bear to each other, are now given. The observations were not taken on the same day as those on which the observations of traffic and accidents were recorded. Nevertheless they fairly represent the proportion of the several classes of vehicles.

Table showing the proportions of the different classes of vehicles passing through the various thoroughfares during 12 *hours, from* 8 *a. m. to* 8 *p. m., on certain days in November,* 1873.

Street.	Percentage to total traffic.					
	Cabs.	Omnibuses.	Railway vans.	Tradesmen's carts.	All other vehicles.	All vehicles.
Cheapside	38	22	17	8	15	100
Poultry	38	28	13	7	14	100
King William street, by Abchurch Lane	29	22	19	8	22	100
Cannon street, by Bush Lane	40	2	28	10	20	100
King William street, north of Arthur street	19	20	25	10	26	100
Gracechurch street, by Talbot court	23	9	31	12	25	100

ACCIDENTS TO HORSES.*

The number of accidents and the average distance traveled before an accident occurred.

The number of horses that fell during the whole period of 50 days, together with the places at which the accidents occurred, and other particulars relating thereto, are given in Table E in the appendix, and may be identified on the plan attached. The general results are:

Asphalt:	
Cheapside	932
Poultry	134
Total on asphalt	1,066
Granite:	
King William street	429
Cannon street	290
Total on granite	719
Wood:	
King William street and Gracechurch street, improved wood pavement	380
Gracechurch street, ligno-mineral pavement	162
Total on wood	542
Total on all pavements	2,327

which gives a daily mean over the various pavements during the 50 days of—

Asphalt:	
Cheapside	18.64
Poultry	2.86
Total on asphalt	21.32

*See Note by Department on page 297.

Granite:

King William street	8.58
Cannon street	5.80
Total on granite	14.38

Wood:

King William street and Gracechurch street—improved wood pavement	7.60
Gracechurch street—ligno-mineral pavement	3.24
Total on wood	10.84

No opinion of value as to the relative safety of the different classes of pavement can, however, be formed by simply comparing the number of horses which fell in any one thoroughfare with the number which passed through it—or by comparing the falls with those which took place in another thoroughfare, inasmuch as the risk of falling which a horse incurs on a pavement necessarily depends on the length of the pavement traversed. With the view, therefore, of arriving at a correct conclusion, the various streams of traffic, as well as the distances traveled, were taken separately, and thus the exact distance which was passed over before an accident occurred was ascertained. These lengths are given with much other detail in Table F in the appendix, but the totals in each street are given the following table:

Table showing the total distance traveled by horses over the different pavements, and the total number of accidents during the 50 days' observations.

Description and situation of pavement.	No. of accidents.	Distance traveled.
Asphalt:		*Miles.*
Cheapside	932	172,783
Poultry	134	31,022
Granite:		
King William street	429	54,683
Cannon street	290	40,884
Wood:		
King William street and Gracechurch street, improved wood pavement	380	169,690
Gracechurch street, ligno-mineral pavement	162	9,461
	2,327	478,523

The aggregate distance traveled by the horses included in the 50 days' observation was, therefore, 478,523 miles. The general result was that a horse might during that time have been expected to travel along the three pavements—in the proportions due to their lengths—a distance of 205 miles before an accident occurred. The distances, however, differed materially on the various pavements, examination showing that a horse might have been expected to travel on the—

	Miles.
Asphalt:	
In Cheapside	185
In Poultry	231
Mean of the asphalt	191
Granite:	
In King William street	127
In Cannon street	140
Mean of the granite	132
Wood:	
In King William street and Gracechurch street, improved wood pavement	446
In Gracechurch street, ligno-mineral pavement	58
Mean of the wood	330

The order of slipperiness during the 50 days was, therefore, ascertained to be:

	Miles.
1. Granite	132
2. Asphalt	191
3. Wood	330

The observations therefore show that a horse might have been expected to travel before it met with an accident the least distance on the granite, a greater distance on the asphalt, and the greatest distance on the wood.

These figures are correct as far as they go; but to adopt them as determining the relative slipperiness of the various pavements, without considerable limitation and correction, would be unsafe. To arrive at a correct opinion it is necessary to make further investigation, in order to see whether any portion of the accidents was due to conditions in which one pavement was more favorably circumstanced than others, apart from the difference resulting from the material of which the pavement was composed. Above all it is necessary to ascertain whether the general results would have been changed if the observations had been extended over a much longer period of time, including other seasons of the year, and every description of weather. With that object the accidents are now investigated and considered under the following sections:

(1) Nature of the accidents to horses.
(2) Effect of harnessing.
(3) Effect of rate of travel.
(4) Effect of gradient.
(5) Effect of condition of surface repair.
(6) Effect of surface cleanliness.
(7) Effect of weather on toe surface.

Before proceeding, however, to these separate considerations, some further information derived from the observations may be usefully given.

It might have been expected that a large proportion of accidents would have occurred at or near to the point of junction of one pavement with another of different character. The observations show that such was not the case to any material extent, excepting in King William street, at the junction of the asphalt with the granite. Even in this case investigation assigns other conditions as in some degree accounting for the large proportion of falls which occurred at that spot.

It might also have been anticipated that many accidents would have occurred at points where the collateral traffic either joins or leaves the main stream; for at those points a horse has not only a direct draft, but has to exert force laterally, and withstand the drag of the vehicle in turning, which in the city streets usually causes the wheels to grind against the curbstones. The returns show that although near to the junction of Bow lane, Bread street, and Gutter lane a somewhat large number of accidents took place, yet at Wood street, Foster lane, and Friday street, where there was a larger collateral traffic, no such excess occurred. Indeed, looking at the returns it would seem that the collateral traffic led to accidents to the horses moving on the main line, by causing them to be pulled up suddenly, rather than itself suffering accidents from turning into or out of the main line. It is probable that the superior safety on the asphalt in the Poultry, to that in Cheapside, is attributable in some degree to the absence of much collateral traffic, although the slower rate of travel in the Poultry was the most important element in causing that result.

NATURE OF THE ACCIDENTS TO HORSES.

It has already been stated that the accidents were at first recorded without explanation of their character, but that for 32 days they were taken under the respective heads of "falls on knees," falls on "haunches," and "complete falls."

The inconvenience caused to the general traffic of a street by an accident to a horse

differs materially. A horse which falls on the knees generally recovers itself speedily, and creates but little obstruction. One which falls on the haunches, and especially on a pavement with little joint or foothold, recovers itself with more difficulty, and is longer in doing so than if it falls on the knees; whilst if it falls on the side it has more frequently than otherwise to be unharnessed before it can regain a standing position, and, therefore, causes more obstruction than either of the other classes of accident.

It is probable that the injury to horses is greater when they fall on the haunches than when they fall on the knees, owing to the strain to which they subject themselves when attempting to rise. This is especially the case when they are in single harness drawing heavily-laden two-wheeled vehicles and fall on a pavement without joints. Complete falls, if sudden and sharp, are probably still more injurious when the pavement on which the accident takes place is a very hard one. Facts on these points are difficult to obtain, but the matter is worthy of serious consideration.

Details of the accidents are given in Table G in the appendix, but the following table gives the general results:

Table showing the numbers of falls on knees, on haunches, and complete falls on the three pavements during 32 days' observation.

Description of pavement.	On knees.	On haunches.	Complete.	Total.
Asphalt	140	107	190	437
Granite	135	22	134	291
Wood	277	10	39	326
Total	552	139	363	1,054

Which gives the following general proportions, viz:

	Per cent.
Falls on knees	52.37
Falls on haunches	13.19
Complete falls	34.44

And separating the accidents as they occurred on the different pavements, the proportions are:

Description and locality of pavement.	Accidents during 32 days' observations.		
	On knees.	On Haunches.	Complete.
	Per cent.	Per cent.	Per cent.
Asphalt: Cheapside, Poultry	32.04	24.48	43.48
Granite: King William street and Cannon street	46.39	7.56	46.05
Wood: King William street and Gracechurch street	84.97	3.07	11.96

This table shows that of falls on knees, the wood had by far the greatest proportion, more than five-sixths of the accidents being of this class, and that asphalt had the fewest falls on knees.

Of falls on haunches, the asphalt had the largest proportion, and was very largely in excess of those on either of the other pavements, and that the wood had the smallest proportion of this class of accidents.

Of complete falls, there were fewest on the wood and most on the granite, but the difference between the asphalt and granite was in this respect small, and on both

asphalt and granite there was something like four times the porportion of complete falls that there were on the wood.

Separating the accidents which occurred respectively on the two wood pavements which were under observation, the following are the results:

	Accidents occuring during 32 days' observations.		
	On knees.	On haunches.	Complete.
	Per cent.	*Per cent.*	*Per cent.*
Improved wood pavement	84.00	3.60	12.40
Ligno-mineral pavement	88.16	1.31	10.53

Thus it appears, generally, that horses traveling on the wood pavement were on the whole subjected to falls of a character less inconvenient to the general traffic of the street, and also less likely to be injurious to the horses, than those traveling on the other two pavements, and that in this respect the ligno-mineral was superior to the improved wood pavement.

It was noticed also, that whatever was the nature of the accident, the horses recovered their feet more easily on wood than they did either on asphalt or granite.

EFFECT OF HARNESSING.

Although it but little affects the end for which this report was prepared, it may be interesting to show how the horses to which the accidents occurred were harnessed.

The observations were taken under the heads of one horse, two, and three or more horse vehicles, and are shown by Tables H and I in the appendix. The general result on all the pavements during the 50 days' observation gives:

	No. of falls.	Percentage of whole.
Falls to horses in one-horse vehicles	1,279	54.96
Falls to horses in two-horse vehicles	927	39.84
Falls to horses in three or more horse vehicles	121	5.20
	2,327	100.00

Assigning these to the various pavements on which the falls took place, the results were:

	Per cent.
Asphalt:	
Cheapsie and Poulry:	
Falls in one-horse vehicles	55.81
Falls in two-horse vehicles	41.56
Falls in three or more horse vehicels	2.63
Granite:	
King William street and Cannon street:	
Falls in one-horse vehicles	58.83
Falls in two-horse vehicles	36.58
Falls in three or more horse vehicles	4.59
Wood:	
King William street and Gracechurch street:	
Falls in one-horse vehicles	48.16
Falls in two-horse vehicles	40.77
Falls in three or more horse vehicles	11.07

Thus, on all classes of pavement the largest percentage of accidents occurred to horses drawing one-horse vehicles. It has already been shown that vehicles drawn by one horse form the largest proportion of the traffic, being, in fact, 71.42 per cent. of the whole, whereas those drawn by three horses or more are but 1.63 per cent. of the whole; and, therefore, as in previous calculations, it is necessary to ascertain the distance traveled by the various classes of vehicles in order to see what was the actual risk incurred under the different modes of harnessing. These distances are shown in detail in Table K, but the general results are that, during the 50 days' observations, a horse might be expected to travel the following distances before it met with an accident:

Table showing the average distance traveled before a horse fell, in vehicles drawn by one horse, two, three, or more horses respectively.

	Miles.
Asphalt:	
Cheapside and Poultry.	
A horse in a one-horse vehicle	179
A horse in a two-horse vehicle	211
A horse in a three or more horse vehicle	116
Granite:	
King William Street and Cannon Street.	
A horse in a one-horse vehicle	138
A horse in a two-horse vehicle	131
A horse in a three or more horse vehicle	72
Wood:	
King William Street and Gracechurch street.	
A horse in a one-horse vehicle	352
A horse in a two-horse vehicle	349
A horse in a three or more horse vehicle	165

The result of the 50 days' observations therefore was:

That on all three classes of pavement the greatest risk of accident was to horses in vehicles drawn by three or more horses.

That on asphalt there was more risk of a horse falling in a one-horse than in a two-horse vehicle, but that on granite and wood the risk was very nearly the same, whether the vehicle was drawn by one or two horses.

It may be observed that in the three-horse vehicles the horses were nearly always in single file, and that in the two-horse vehicles the animals were almost invariably abreast, the exception being principally brewers' drays and market gardeners' carts and wagons.

EFFECT OF RATE OF TRAVEL.

Fast traveling is the cause of accidents in thoroughfares of much traffic, such as those of the city of London, inasmuch as it frequently involves either sudden reduction of speed or actual stoppage of the horse, which is more or less difficult according to the degree of foothold that the pavement affords. It is more difficult to stop a horse on asphalt than on granite or on wood.

Of the streets under observation, that in which the traffic usually moved with the greatest speed was King William street from Common street to Lombard street. The carts which loaded and unloaded there were few.

Cheapside at certain hours of the day and on a portion of its length only had a somewhat quick traffic along its center, but not so quick as the traffic over the narrow part of King William street. In the Poultry the traffic was uniformly slow; which fact in some degree may explain the other fact observed—that a horse saw

shown to travel there before an accident occurred a greater distance than in Cheapside. Both pavements were of the same material and in the same condition of repair.

In King William street and Gracechurch street, where they were paved with wood, the traffic during the twelve hours in which observations were taken was, northwards of Arthur street, for the most part slow, and southwards of that street perhaps a little quicker in the center during some hours of the day, but not materially so.

The granite was, therefore, on the whole, more disadvantageously placed in respect of speed of travel than either the asphalt or the wood; but a careful examination of the accidents does not enable me to state what proportion of these was attributable to this cause, although there is little doubt that in King William street (granite) some accidents were due to speed, especially as the surface of that pavement was in bad condition.

EFFECT OF GRADIENT.

The power required to draw a load increases directly a level surface is departed from, but the difference is not appreciable when the gradient is slight. The power varies according to the nature of the road surface, the state of repair, the way horses are laden and harnessed, and other conditions. Speaking generally and in round numbers, it has been demonstrated that a horse can, with the exertion of the same force, draw up a gradient of 1 in 100 about nine-tenths of the load which it can draw on a level surface, and about eight-tenths of the same load if the gradient be 1 in 50. After that the tractive power needed increases more rapidly, for on a gradient of 1 in 30 a horse can draw little more than six-tenths of the same load that it can on a level surface. For practical purposes a rod, ever if it be paved with asphalt, may be considered to have a safe and convenient inclination at 1 in 60; but under all conditions of surface and gradient the extent to which a horse is laden is a material consideration. The chance of an accident to a horse is greater when it is heavily laden than when lightly laden. It its necessary therefore to inquire further into the nature of the gradients of the various thoroughfares under observation in order to see if one street was more favorable than another.

Asphalt.—The gradients of the asphalt in Cheapside and the Poultry were excellent; there being but a very short length at the western end of Cheapside which was as steep as 1 in 58.

Granite.—The gradients in King William street were for the most part excellent. In Cannon street there were 326 feet lineal, or about 40 per cent. of its length, of which the gradients varied from 1 in 30 to 1 in 31. Taking both granite pavements, this indifferent gradient was 22 per cent. of their entire length.

Wood.—On the wood pavements the gradients south of Arthur street were excellent. In the vicinity of King William statue there were various lengths, amounting to 12 per cent. of the total length of the wood, which had gradients of from 1 in 30 to 1 in 37. Moreover, in the vicinity of the statue, where the direct gradients were the worst, the pavement at several places had transverse slopes, varying from 1 in 20 to 1 in 38. Nearly the entire surface between Eastcheap and a short distance south of the statue had objectionable cross gradients.

From what has been stated as to the effect of gradient, it was not to be expected that accidents would be traceable to gradients less steep than 1 in 60. The observations do not show that accidents increased in regular proportion as the gradients became sharp, whether above or below 1 in 60; but they indicate that when the gradients were from 1 in 30 to 1 in 50 a larger proportion of accidents occurred both upon the granite and wood than elsewhere on the same lines where the gradients were better.

Thus the mean of the 50 days' observations showed that a horse might be expected to travel 103 miles before falling on the western end of Cannon street, where the gradients were 1 in 30 and 1 in 31, assuming it to have traveled both uphill and down-

hill; whilst eastward in the same street, where the gradients varied from 1 in 61 to 1 in 841, it might be expected to travel 187 miles before it fell. The mean of all the granite pavements gave a distance of 132 miles before an accident happened to a horse.

It was shown that in Cannon street accidents on the inferior gradients oftener occurred to horses going uphill than to those going downhill.

The observations, it is true, show an excess of accidents on the granite at some parts where the gradients were better than those just referred to; as, for example, at the western end of King William street, by the church of St. Mary Woolnoth, which had a gradient of 1 in 54; but there the excess was probably attributable to the state of repair of the surface, in conjunction with the speed of travel in that thoroughfare, and also to its immediate proximity to the asphalt.

On the wood pavement in the vicinity of the statue, where the gradients were 1 in 30 and 1 in 37, and where the objectionable cross gradients existed, the records are mixed with those referring to adjoining lengths of roadway having gradients of from 1 in 30 to 1 in 260; but the average of the whole shows that a horse might be expected to travel in that neighborhood 244 miles before it fell, whereas on that part of the pavement which lies between the statue and London bridge, on which the worst gradient was 1 in 56, the distance which a horse might be expected to travel was 784 miles.

The accidents on the Ligno-Mineral pavement in Gracechurch street were at the rate of 1 in 58 miles. There the gradient was 1 in 49. If any accidents may have been attributable to this gradient, it can not alone account for the large number occurring at this spot.

The asphalt pavement was, therefore, as regards gradients, more favored than the others. The next in order was the granite. The wood pavement was, on the whole, the least favored.

EFFECT OF CONDITION OF SURFACE REPAIR.

The state of repair of the surface of a pavement affects its safety. For instance, more horses may be expected to fall on a granite pavement that has many sunken places, and the general surface of which is worn smooth, which is the condition of nearly all granite pavements when they need relaying, than on one which has an even surface and is somewhat rough to the foot, which is the condition of a *new* granite pavement.

It has already been stated that the surfaces of both the asphalt and the wood were in excellent condition, and that those of the granite were not. Cannon street was not, however, in such a state as to lead to the belief that the accidents taking place in it were materially attributable to the state of repair; but the pavement in King William street being under order to be renewed, was undoubtedly in such a state as may have caused some, for neither the traffic nor the gradient can have caused the excess of accidents that occurred in that portion of the street where the pavement was in the worst condition.

Had the wood pavements been in an indifferent condition of surface repair more accidents would probably have taken place on them than actually occurred during the 50 days' observations.

As regards asphalt the case is somewhat different. Asphalt is not likely at any time so to vary in condition as to increase materially the number of accidents taking place on it. If holes show themselves of any size or depth in this material, and they be not speedily repaired, they are quickly enlarged by the traffic, and the destruction of the pavement at those spots soon follows. It will be absolutely necessary to keep at all times the surface of the asphalt comparatively smooth, and therefore the number of accidents taking place on it is not likely to be increased by condition of surface repair.

In comparing the results of the observations for general application, it must then be borne in mind that in respect of surface repair the asphalt and the wood were more advantageously placed than the granite.

EFFECT OF SURFACE CLEANLINESS.

The thoroughfares of the city of London are now, speaking generally, perhaps as clean as streets of so much traffic can be kept, except by washing them daily. Cleanliness has a very important influence on the slipperiness of all pavements. Its effect, however, differs materially, in some cases being favorable, in other cases unfavorable to foothold, this quality depending largely on the moisture of the surface. A description of the way in which the streets were cleansed during the observations has been given in a previous part of the report.

As an example: For safety asphalt generally can not be too clean, but a granite pavement when very clean may, under certain atmospheric conditions, be much more slippery than when dirty. If clean there are occasions when the iron from the horses' shoes and from the tires of the wheels is caught by the surface of the stones, which then acquires a metallic appearance; the pavement is then most slippery. If it be not clean the dust or dirt interposes as a medium between the surface and the horses' feet, and the slipperiness is in a certain degree prevented.

A similar metallic appearance may be noticed on asphalt in very dry and cold weather if the roadway be kept clean, and it is observable especially at night. But this condition does not appear materially to affect the slipperiness of the asphalt, or certainly not nearly in the same degree that it does granite.

On the other hand, if granite be dirty and the dirt be slightly damp, it is more slippery than when clean and slightly damp. Asphalt is similarly affected, but in a very much worse degree.

The safety of wood is little affected, whether it be clean or not, so long as the surface is dry. If dirty, wood becomes just after rain much more slippery than at any other time, which is not the case if it be perfectly clean.

These remarks on surface cleanliness are made because many of the accidents occurring on the granite pavement during the 50 days' observations would certainly not have taken place had the pavement not been kept so clean. Similar cleanliness was beneficial to the other pavements. On the whole, the cleanliness under the circumstances to be narrated in the section which treats of the effect of weather on the surface, will be seen to have placed the granite at a disadvantage compared with the other pavements.

THE EFFECT OF WEATHER ON THE SURFACE.

The surfaces of all pavements are largely affected by the weather. A cold dry wind, a hot sun, a heavy or a light rain, a thick fog, or even a very moist atmosphere, causes them to be more or less slippery, according to the character of the pavement, and other conditions. Moisture plays a very important part in the safety of traveling. For example: During a continuation of a cold, dry wind, with a somewhat hot sun (an atmospheric condition prevailing largely in the spring), neither asphalt nor wood is slippery, whilst granite, if it be worn smooth, which is its ordinary condition in London, and if it be clean, is in its very worst state of slipperiness. If light rains ensue the slipperiness of the granite is much reduced; the wood will then enter into its most slippery state, but for a short time only; as the mud soon begins to peel from the surface, whilst the asphalt becomes for a time almost as slippery as a pavement can be, times of frost or snow excepted, and continues so until the mud becomes nearly liquid. If the rain falls heavily the granite becomes in its safest condition; the asphalt much safer than when merely damp; and the wood approaches in safety its condition when actually dry.

Again, as soon as fine weather comes after much rain, the street dirt clings to the surface of the wood on account of that material retaining moisture; but the wood

does not always become slippery whilst this process is going on. The mud in the joints of the granite retains its moisture for a long time if the atmosphere be damp, and causes that pavement for a certain time to be more slippery than when wet. Asphalt, which from its impermeability soon dries, enters again quickly into its safest state, but not until it has passed through an intermediate stage between wetness and dryness, during which it is quite as slippery as when rain first falls on it after drought; unless, indeed, the rain has fallen heavily and washed it perfectly clean.

It must therefore be understood that these conditions of slipperiness are subjected to manifold changes, according to the condition of the weather and the state of cleanliness of the surface of the pavement.

With a view of ascertaining how the number of accidents was affected by the moisture on the surface, observations on that head were recorded throughout the day and also each time an accident occurred. Owing to the many gradations between positive dryness and positive wetness, and the condition of each surface varying many times during the day, uniformity of description was not obtained in the records. Nevertheless the records admit of the accidents being arranged generally under certain classes of surface moisture, and of some general approximate results being arrived at.

It is then of importance in judging of the relative safety of the different pavements to give consideration to the state of the weather whilst the observations were in hand, in order to see whether it was such as was likely to be more favorable to one pavement than another. Indeed, without full consideration of this point all conclusions as to the relative safety of the pavements would be fallacious; the subject of the weather will, therefore, be treated more fully than it has yet been.

As regards wind, its direction frequently shifts for short periods during the 24 hours; and there are, therefore, various directions recorded during one day. This was the case during the period of the observations of accidents, as will be seen by Table E. Examination shows that the wind was either from the east, northeast, or southeast during a large proportion of the time; being in fact in those directions on 38 days out of 50, or 76 per cent. of the whole.

During the 50 days' observations there was, according to the registrar-general's returns, about 18 per cent. less than the usual proportion of rainy days, taking the average of the year, and about 14 per cent. less than the average during the same months. The police returns of the number of wet days is still less, inasmuch as they only recorded the rain when it fell during the 12 hours' observations, but what is even more important is that the quantity of rain was very noticeably less, inasmuch as it was but about 53 per cent., or little more than one-half of that which usually falls in the same time at that season of the year. Moreover, a considerable portion of it fell during the night when the observations of accidents were discontinued. It must above all be noticed that there was an almost entire absence of days in which rain fell at intervals in small quantities, or drizzling, although such days are very frequent in London during the year.

As regards temperature, it was a trifle lower than the average of years, and the atmosphere was on but few occasions much charged with moisture. The weather was in fact, in its main features, quantity of rain excepted, that which usually occurs in London in the spring, when dry winds are accompanied by a warm sun, owing to which moisture soon passes away from street surfaces.

The weather, therefore, on the whole was very favorable to asphalt, there having been a great absence of that weather which creates a damp surface and causes that material to be in its most slippery state, and was very unfavorable to granite, inas, much as that material, if clean, during dry, cold winds is in its most slippery condition. As regards wood, the absence of rain was decidedly favorable to it, although moisture does not appear to render that material relatively so slippery or to play so important a part as regards safety as it does with asphalt and granite.

Table E in the appendix shows the accidents which took place under different conditions of surface moisture. The general results are:

Mean of the 50 days' observations, including all those conditions of weather and surface moisture which occurred during that time.

Situation.	Distance traveled before a horse fell.
	Miles.
Granite—King William street and Cannon street	132
Asphalt—Cheapside and Poultry	191
Wood—King William street and Gracechurch street	330

These results have been given before, but are repeated here for facility of reference.

Separating the accidents under three heads, namely, those which occurred when the pavements were dry, those which occurred when they were merely damp, as during very slight rain and after rain had ceased, and after the streets had been watered, and those which took place either when rain was falling or whilst the surfaces were wet, the following results were obtained:

Table showing the comparative slipperiness of the various pavements under three different conditions of surface moisture.

Situation.	Description of pavement.	Distance traveled before a horse fell.
		Miles.
Days when surface of pavements was generally dry:		
King William street and Cannon street	Granite	78
Cheapside and Poultry	Asphalt	223
King William street and Gracechurch street	Wood	646
Days when the surface of the pavements was damp in different degrees:		
Cheapside and Poultry	Asphalt	125
King William street and Cannon street	Granite	168
King William street and Gracechurch street	Wood	193
Days when the surface of pavements was wet:		
Cheapside and Poultry	Asphalt	192
King William street and Gracechurch street	Wood	432
King William street and Cannon street	Granite	537

The following table groups the results in a different order:

Table showing the degree of slipperiness of each pavement under three conditions of surface moisture, beginning in each case with that condition under which the pavement was the most slippery.

	Falls.	Miles.
Asphalt:		
1st. When pavement was damp in different degrees	1	125
2d. When pavement was wet	1	192
3d. When pavement was dry	1	223
Granite:		
1st. When pavement was dry	1	78
2d. When pavement was damp in different degrees	1	168
3d. When pavement was wet	1	537
Wood:		
1st. When pavement was damp in different degrees	1	193
2d. When pavement was wet	1	432
3d. When pavement was dry	1	646

The following table groups the results in another order:

Table showing the slipperiness of all the pavements under various conditions of surface moisture which occurred during the 50 days' observations, beginning with the most slippery.

Situation	Description of pavement.	Distance traveled be ore a horse fell.	Condition of surface as regards moisture.
		Miles.	
King William street and Cannon street	Granite	78	Pavement dry.
Cheapside and Poultry	Asphalt	125	Pavement damp.
King William street and Cannon street	Granite	168	Do.
Cheapside and Poultry	Asphalt	192	Pavement wet.
King William street and Gracechurch street	Wood	193	Pavement damp.
Cheapside and Poultry	Asphalt	223	Pavement dry.
King William street and Gracechurch street	Wood	432	Pavement wet.
King William street and Cannon street	Granite	537	Do.
King William street and Gracechurch street	Wood	646	Pavement dry.

From the foregoing summaries it appears—

That asphalt was most slippery when merely damp, and safest when perfectly dry; that a horse might be expected to travel on the asphalt without an accident nearly twice the distance when the pavement was dry that it could do when damp, and that the difference between the safety of asphalt when wet and dry was not considerable.

That granite was most slippery when dry, and safest when wet; that a horse might be expected to travel on granite without accident nearly seven times the distance when the pavement was wet than when dry, and that the granite was about twice as safe when merely damp as when dry.

That wood was most slippery when damp, and safest when dry; that a horse might be expected to travel on the wood more than three times the distance when the pavement was dry than when damp, and that the wood was more than twice as safe when wet as when damp.

Here it will be convenient to show the difference between the slipperiness of the two wood pavements under observation.

About 1,394 feet lineal, or 94 per cent. of the entire length of the wood, was that of the improved wood pavement. The remaining 87 feet lineal, or 6 per cent. of the whole, was the ligno-mineral pavement.

It will be seen that altogether 380 horses fell on the improved wood pavement, and 162 on the ligno-mineral pavement. Dealing with these figures in the same manner as before, we find that a horse might be expected to travel before it met with an accident 446 miles on the improved wood pavement, and 58 miles on the ligno-mineral pavement. In other words, the improved wood was nearly eight times safer than the ligno-mineral under such conditions of weather and traffic as took place during the 50 days' observations.

The ligno-mineral pavement had a gradient of 1 in 49, which was certainly not so good as a considerable length of the other pavement, but the improved wood had 267 feet in length with gradients varying from 1 in 30 to 1 in 37, which are very much worse for traction than 1 in 49. In addition to this, it had the disadvantage of the bad cross gradients, and it is evident, therefore, that gradient can not account for the large proportion of falls which occurred on the ligno-mineral pavement.

The traffic on both of the pavements was much the same in character, and passed at about the same speed; and as the surfaces of both were in very nearly equally good repair, one was not more disadvantageously placed than the other in these respects.

Many omnibuses turn round on the ligno-mineral pavement to take up their station on the eastern side of Gracechurch s reet, and it was at first imagined that accidents might have been attributable to that cause. On looking into the matter, it was found that the omnibuses were for the most part empty, or nearly so, and that they

turned round slowly, so that accidents did not occur to their horses in any larger proportion than to the other traffic. Even if some accidents were caused by this, they would not account for the excess.

It is important to separate these accidents. If those which occurred on the ligno-mineral are eliminated, and those which occurred on the improved wood are alone used for comparison with the asphalt and granite, it will be seen (as shown in Table F in the appendix) that a horse might have been expected to travel during the 50 days' observations 446 miles on the improved wood pavement before it met with an accident, instead of 330 miles as shown by the summaries, in which both woods are taken together, and that the order of slipperiness would therefore be—

	Miles.
1. Granite	132
2. Asphalt	191
3. Wood	446

CONCLUDING REMARKS.

A consideration of those sections of the report in which the pavements are referred to under the various conditions that affect their slipperiness shows how wrong it would be to take the first broad results of the observations as an exact measure of the relative safety of the pavements at all times and seasons. It would not, however, be possible to substitute for the results now placed before the commission anything in a similarly exact shape, unless observations were taken over the three classes of pavements in other seasons of the year. All that now can be done is to take the figures given by the 50 days' observations, and after studying them by the side of those modifying circumstances which have been set forth in the various sections of the report, to draw such general conclusions as may seem to be warranted.

The first thing, therefore, is to consider the effect of those conditions in which one pavement was more favorably placed than the others. Conclusions on these points have been given in the sections in which they have been separately treated of, and taking them in the order of the report their general results are as follows:

As regards the effect of the speed of traffic, the wood and asphalt were as nearly as possible under similar conditions. The granite, having at one place a higher speed, and the pavement there not being in so good condition as the others, was placed in less favorable circumstances.

As regards gradient, the asphalt was the most favorably placed, the granite the next so, and the wood the least.

As regards surface repair, the asphalt and the wood were in equally good condition, while the granite was in a very inferior condition.

As regards cleanliness of surface, all three pavements were equal so far as the materials of which they were composed enabled them to be.

As regards weather, it was very much in favor of the asphalt, was generally favorable to the wood, and was very unfavorable to the granite.

Taking the whole group of conditions into account, the asphalt was the most advantageously placed, the wood was the next so, and the granite was the worst placed.

On the average of the whole 50 days' observations the granite was found to be the most slippery, the asphalt the next so, and the wood the least.

Separating the accidents under three conditions of surface as regards moisture, it appears:

That asphalt was most slippery when merely damp and safest when dry.

That granite was most slippery when dry and safest when wet.

That wood was most slippery when damp and safest when dry.

That when the surface of the pavements was generally dry granite was the most slippery and wood the least slippery.

That when the surface of the pavements was damp in different degrees asphalt was the most slippery and wood the least slippery.

That when the surface of the pavements was wet asphalt was the most slippery and granite the least slippery.

That on the whole wood was less slippery than either asphalt or granite.

That if the observations on the ligno-mineral paving be eliminated, and the improved wood pavement alone taken for comparison, wood was on the whole less slippery than either asphalt or granite in a marked degree, it only being inferior to granite when the pavements were wet, and the difference then between the wood and the granite being inconsiderable.

That of those accidents which are most obstructive to the traffic as well as most injurious to the horses, asphalt had the greatest proportion, granite the next, and wood the least.

That the greatest proportion of accidents on all the pavements was to horses in vehicles drawn by three or more horses.

That had the granite been under as favorable conditions as the asphalt and the wood the results would have been more in favor of the granite, although to what extent can not be stated.

Finally, I beg to state that it would be desirable to make observations at a differ ent season of the year to that in which those herein recorded were taken.

I have the honor to remain, gentlemen, your most obedient servant,

WILLIAM HAYWOOD,
Engineer and Surveyor.

ASPHALT PAVEMENTS IN LONDON.

SEWER OFFICE,
Guildhall, April 18, 1873.

To the streets committee of the honorable the commissioners of sewers of the city of London:

GENTLEMEN: In pursuance of your instructions I have carefully inspected the whole of the asphalt pavements which have been laid within the city of London, and beg to lay before you my report upon their present condition.

I have put my report in the shape of a table, which gives the dates when the pavements were laid, their area, first cost, the traffic which passes over them, and other particulars which may be found useful in considering questions relating to asphalt pavings generally.

Portions of some of the pavements have been cut out under my direction, in order to ascertain whether they had lost materially in thickness. In nearly all cases a slight diminution in thickness was found to have taken place, and in one instance to such an extent as to lead to the inference that it could not have been properly compressed when laid, or that it was not laid of the depth intended; in one or two instances, on the contrary, the thickness was found to be the same or even greater than that at which they were nominally laid. Taking, however, into account the position in which the various openings were made for examination, and the circumstances which affect the consideration, there is no doubt that the asphalts have somewhat diminished in thickness under the wear of the traffic, but owing to inequalities when they were first laid, and to the compression which takes place in all those laid in the shape of heated powder, it would be difficult to ascertain the exact loss without making a very large number of openings.

The asphalt companies upon application to them have given some account of the repairs done since the pavements were laid, but not in such a shape as it would be desirable to have it; it is, however, I have reason to believe, the best account that they can give.

Reports from the inspectors of pavements have also been made to me, an abstract of which report is given in the table, those officers having long since been directed by me to notice carefully the repairs which were made to the pavements; but the

companies being bound to maintain the pavements for a given number of years, can repair them whenever they think needful, without consulting me, provided they do not interfere with the traffic in their operations, and as repairs are generally performed at night, or very early in the morning, it is possible that many may have escaped the notice of the inspectors.

In considering the table, the following explanations should be held in view:

Where a pavement is stated to be in a generally good condition, no account is taken of the transverse depressions in the compressed asphalts or of the lines of joint in the other asphalts consequent upon the mode of laying or forming the pavements.

In compressed asphalts repairs after a time are not readily noticeable, whilst those in mastic asphalts are more easily seen.

Where "holes" or "short holes" are mentioned, it must be understood that the asphalts are not worn down to the concrete foundation.

Minute holes are noticeable in compressed asphalts shortly after they are laid, which holes after a time seem to close up or disappear, whilst others open; the cause of this (which is probably due to foreign substances) has never been satisfactorily explained, but no account is taken of these small holes in my report as to condition.

The larger holes upon compressed asphalts are in most cases depressions caused by the traffic, and do not necessarily indicate surface wear; in the mastic asphalts, on the contrary, they are for the most part the result of disintegration and wear of the surface.

There are now altogether twenty-five streets or portions of streets in the city of which the carriageways have been paved with asphalt; one of the pavements had been down 3 years and 9 months, two for 2 years and 2 months, eighteen under 2 years, four under 1 year, and 5 under 6 months, at the time of my inspection.

I have the honor to remain, gentlemen, your most obedient servant,

William Haywood,
Engineer and Surveyor.

Table showing the various asphalts which have been laid in carriageways within the city of London, April, 1873.

Name.	Date.	Total carriage-traffic from 8 a. m. to 8 p. m.	Area.	First cost of pavement including foundation, per yard superficial.	Laying was completed.	Time down, to March 1, 1873.	Returns supplied by companies as to repairs done since pavement was laid.	Inspectors' reports as to repairs since pavement was laid.	Engineer's report as to present condition and general results of examination into loss of thickness by wear and compression.
			Sup. yds.	*s. d.*		*Yrs. Mo.*			
Val de Travers asphalt. (Compressed.)									
Poultry and Cheapside: Poultry .... Cheapside	July 5, 1872 Feb. 7, 1872	7997 8949	7938	18 0	Dec. 9, 1870	2 $2\frac{3}{4}$	Total cost of repairs over the whole surface $3\frac{3}{4}d.$ per square yard during 1872.	Is continually being repaired at night.	Poultry: Its nominal thickness when laid was $2\frac{1}{4}$ in. Of two samples cut out recently the thicknesses varied from $1\frac{5}{8}$ in. to $1\frac{13}{16}$ in. in the groove worn next curb, and from $1\frac{1}{2}$ in. to $1\frac{7}{8}$ in. at a distance of 3 ft. from curb; many holes over the entire surface. The channels on both sides are very much worn, and it will require extensive repairs during the year. Cheapside: Its nominal thickness when first laid was $2\frac{1}{4}$ in. In three samples cut out recently the thicknesses varied from $1\frac{5}{16}$ in. to $1\frac{7}{16}$ in the groove worn next the curb, $1\frac{3}{4}$ in. to $1\frac{13}{16}$ at 3 ft. from curb, and an average of $1\frac{7}{8}$ in. in the center of the carriageway. The weight of a piece 1 ft. square was 21 lbs. 15 oz., or 197 lbs. 7 oz. per superficial yard. The channels are somewhat worn, and the entire surface of this pavement has many small holes, which have principally shown themselves within the last 6 months. Very extensive repairs will be needed during the year.
Old and New Broad streets: Old Broad street .... New Broad street........	Feb. 7, 1872 Apr. 1, 1873	2473 1515	3671	16 0	Mar. 25, 1871	1 $11\frac{1}{4}$	Total cost of repairs over whole surface $\frac{3}{4}d.$ per square yard during 1872.	No repairs done.	Old Broad street: Its nominal thickness when laid was 2 in. Its present thickness at the center of carriage-way is $1\frac{11}{16}$ in., and a sample 1 ft. square weighed 19 lbs. $8\frac{1}{2}$ oz., or 175 lbs. $12\frac{1}{4}$ oz. per superficial yard. A few small holes, but otherwise in good condition.
Throgmorton street, narrow portion at western end.	....do	661	150	16 0	Mar. 30, 1871	1 11	None	No repairs done.	The channels somewhat worn, the pavement otherwise in good condition.
Milk street	....do	516	297	16 0	Mar. 22, 1871	1 $11\frac{1}{4}$	None	Repaired in one or two places during the year.	One or two holes on surface. Channel at one place somewhat worn, but surface otherwise in good condition.

Table showing the various asphalts which have been laid in carriageways within the city of London, April, 1879—Continued.

Name.	Date.	Total carriage traffic from 8 a.m. to 8 p.m.	Area.	First cost of pavement including foundation, per yard superficial.	Laying was completed.	Time down, to March 1, 1873.	Returns supplied by companies as to repairs done since pavement was laid.	Inspector's reports as to repairs since pavement was laid.	Engineer's report as to present condition and general results of examination into loss of thickness by wear and compression.
Val de Travers asphalt (compressed)—Continued.			*Sup. yds.*	*s. d.*		*Yrs. Mo.*			
Russia row	April 1, 1873	97	80	16 0	Mar. 22, 1871	1 11½	None	Repaired in one or two places during year.	In good condition.
Queen street	Feb. 7, 1872	2292	799	16 0	Apr. 27, 1871	1 10	None	None of any consequence.	Its nominal thickness, when first laid, was 2½ in. The sample cut out averages 1⅞ in. thick, and weighs 16 lbs. 10 oz. to the square foot, or 149 lbs. 10 oz. per superficial yard. The surface is somewhat worn at the northern end, but in fair condition generally. The southern end has been cut about and damaged by alterations of gullies and pavements consequent upon widening the street.
Old Bailey	Feb. 6, 1872	2903	402	16 0	May 2, 1871	1 10	None	None	Surface generally in good condition.
Gracechurch street: By St. Peter's alley; By Ship Tavern passage.	Apr. 3, 1873; ...do	4824; 4650	2659	17 0	July 22, 1871	1 7½	Total cost of repairs over whole surface, 2½*d.* per square yard in 1872.	Frequently repaired at south end.	There are numerous small holes at the southern end, especially near to Fenchurch street; numerous depressions toward the northern end near to Cornhill, where the street is narrow. The surface generally is in good condition, but is not so even or good as some other of the pavements of this company.
Finsbury pavement and Moorgate.	Mar. 3, 1873	5361	3861	16 0	Aug. 18, 1871	1 6½	None	Trifling repairs.	There are small holes over the surface of this pavement, but it is generally in good condition.
Moorgate street	...do	6000	1028	16 0	...do	1 6½	None	...	The nominal thickness when laid was 2 in. The sample cut out averages 1⅜ in. thick, and weighs 21 lbs. 0½ oz. per square foot, or 189 lbs. 4½ oz. per superficial yard. There are but few small holes in this pavement, and the surface is in a very good condition.
Wood street	Apr. 4, 1873	980	1492	16 0	Sept. 7, 1871	1 5½	None	None of consequence.	There is wear in the channels throughout the street, and a few small holes, but it is otherwise in good condition.

London wall:									
By Little Winchester street.	....do	2262	3165	16 0	Oct. 18, 1871	1 4½	None	Slight repairs but none for some time past.	In the narrow portion of this street a depression is visible in the center of the carriageway throughout its length, which may be partially due to the sinking caused by excavating for a gas pipe trench. There are also some short holes over the surface, which is otherwise generally in good condition.
By Circus place	....do	2852							
Threadneedle street, near Finch lane.	Apr. 9, 1873	3696	485	(*)	May 31, 1869	3 9	None	Nine very small repairs have been made since the pavement was first laid down, their total area being 3¾ yards superficial.	The nominal thickness when laid was: Mastic ½ in., compressed asphalt 2 in. making a total thickness of 2½ in. The first sample cut out recently, averaged: Mastic ¾ in., compressed asphalt 2¼ in, making together 3 in., and weighed 32 lbs. 15½ oz. to the square foot, or 296 lbs. 11½ oz. per superficial yard, including the mastic. The second sample taken averaged: Mastic ¼ in., compressed asphalt 2 in., making together a thickness of 2¼ in., and weighed 21 lbs. 6½ oz. per square foot, or 192 lbs. 10½ oz. per superficial yard, including the mastic. This asphalt appears to have been laid very irregularly in thickness. This pavement was the first laid in the city, and was done at the sole expense of the asphalt company. There are a few holes in places, but it is generally in a good surface condition.
Threadneedle street:									
Eastern end...............	....do	3696	439	16 0	Dec. 22, 1871	1 2¼	None	The portion in narrow way is frequently repaired.	When laid its nominal thickness was 2 in. The sample taken recently gave a thickness of 1 in. in the channel next the curb, and 1⅛ in. at 3 ft. from the curb, and weighed on an average 179 lbs. 9 oz. per superficial yard. The channels throughout the carriageway are deeply worn; there are two well-marked lines of depression or wear running along the center of the street where the outer wheels of the vehicles usually run. There are many depressions or short holes towards the eastern end, and generally the whole surface shows signs of much wear.
Central portion (previously laid by the Maestu Asphalt Company).	....do	3696	281	16 0	Jan. 26, 1872	1 1¼	None		
Mansell street	Apr. 7, 1873	498	734	16 0	Oct. 27, 1871	1 4	Total cost of repairs over whole surface, 3d. per square yard; pavement was laid in very bad weather.	One slight repair done.	A few small holes, otherwise the surface is in good condition.

* Laid by company free of charge.

Table showing the various asphalts which have been laid in carriageways within the city of London, April, 1873—Continued.

Name.	Date.	Total carriage traffic from 8 a. m. to 8 p. m.	Area.	First cost of pavement, including foundation, per yard superficial.	Laying was completed.	Time down, to March 1, 1873.	Returns supplied by companies as to repairs done since pavement was laid.	Inspectors' reports as to repairs since pavement was laid.	Engineer's report as to present condition and general results of examination into loss of thickness by wear and compression.
Val de Travers asphalt (compressed)—Continued.			*Sup. yds.*	*s.* *d.*		*Yrs. mo.*			
Mansion House street	....do	13767	3043	16 0	June 21, 1872	8¼	Total cost of repairs over whole surface, ⅛d. per square yard.	Slight repairs done.	Wear in the channels next the Mansion House, and generally on the surface opposite to that building. The surface is otherwise in good condition. This pavement has been added to once, owing to widening the street.
Princes Street:									
In place of Trinidad asphalt.	Feb. 15, 1872	5,628	340	14 8¾	Nov. 16, 1872	3½	None	None	In good condition.
In place of the patent British asphalt.	....do	5,628	371	14 9¾	Dec. 22, 1872	2¼	....do	....do	Do.
Val de Travers asphalt (mastic).									
George yard	Apr. 7, 1873	58	232	12 0	Apr. 1, 1871	1 11	....	No repairs done.	Small depressions over the surface, but it is generally in good condition.
Montrotier asphalt (compressed).									
Princes street	Feb. 15, 1872	5,628	347	15 0	Aug. 14, 1872	6½	None	None	Nominal thickness when laid was 2¼ inches. Of two samples taken recently, the thicknesses varied from 1½ to 2 in., a square foot weighing 15 lbs. ½oz., or 135 lbs. 4½ oz. per superficial yard. The pavement is in good condition.
Société Française des asphaltes (compressed).									
Princes street	....do	5,628	325	14 9	July 18, 1872	7½	....do	....do	Its nominal thickness when laid was 2½ in. and its present thickness varies from 2¼ to 2⅝ in., a square foot weighing 25 lbs. 12 oz., or 231 lbs. 12 oz. per superficial yard. The surface is unusually wavy, owing probably to want of skill in laying it, but it is generally in good condition.

Limmer asphalt (mastic).									
Lombard street	Feb. 25, 1872	2,499	1,153	16 0	May 18, 1871	1 9½	About 82 yards superficial ¼ to ½ inch in thickness in 1872.	Has been extensively repaired during the last 3 months, at the eastern end more particularly.	Its nominal thickness when laid was 2-in. The sample taken recently averaged 1⅞ in. in thickness and weighed 21 lbs. 2 oz. per square foot, or 190 lbs. 2 oz. per superficial yard. The channels on both sides of this street throughout its length are more or less worn; there are many short holes in the center of the carriageway, especially at the western end; some also at its eastern end near to Fenchurch street.
Moorgate street	Mar. 3, 1873	6,000	1,038	16 0	Sept. 6, 1871	1 5¾	Repairing by water-boxes about 2 yards superficial, and about 80 yards of surface renewed ½-inch thick.	Has been extensively repaired during the last 3 months.	Considerable indications of surface wear in the center of the street; a few bad holes and depressions, but in other respects the surface is good.
Cornhill	Apr. 3, 1873	3,507	3,333	15 0	Mar. 6, 1872	11¾	Laying about ½ in. on 3 yards of surface which had become depressed.	None of consequence.	There is considerable wear along the center of the carriageway upon the line which the traffic generally takes if the street is not too full. This wear has left the surface rough to the feet. The channels are slightly worn.
Barnett's asphalt (mastic).									
Moorgate street	Mar. 3, 1873	6,000	1,057	13 6	Oct. 14, 1871	1 4½	Was repaired in 1871 at its junction with the granite sets in Lothbury. Several small repairs have been done on the southern portion, which was laid during the continuance of heavy rains.	Has been extensively repaired during the year.	Its nominal thickness when first laid was 2½ in. The sample recently taken averages 2 3/16 in. thick, and weighs 23 lbs. 9½ oz. per square foot or 212 lbs. 5½ oz. per superficial yard. There are many small holes, especially at its southern end, where large repairs have been made; the lines of joint are unusually visible. This pavement towards its southern end was laid in very bad weather.
Carter lane	Apr. 4, 1873	317	757	11 6	Sept. 7, 1872	5¾	No repairs done.	None	Surface in good condition.
Lothbury	Apr. 8, 1873	1,612	2,384	10 6	Oct. 10, 1872	4¾	Some large patches, in consequence of adverse circumstances in laying, were almost immediately relaid.	Large portions being badly laid or of bad material have been taken up and relaid, and this is still being done.	The surface is exceedingly variable, in some parts being smooth and in others rough; where rough there are signs of wear; the western portion is the worst.

Table showing the various asphalts which have been laid in carriageways within the city of London, April, 1873—Continued.

Name.	Date.	Total carriage traffic from 8 a. m. to 8 p. m.	Area.	First cost of pavement, including foundation, per yard superficial.	Laying was completed.	Time down, to March 1, 1873.	Returns supplied by companies as to repairs done since pavement was laid.	Inspectors' reports as to repairs since pavement was laid.	Engineer's report as to present condition and general results of examination into loss of thickness by wear and compression.
Barnett's asphalt (mastic)—continued.									
			Sup. yds.	*s. d.*		*Yrs. mo.*			
Bishopsgate street within...	Apr. 7, 1873	6,048	4,288	10 6	Dec. 21, 1872	2¼	None	None	There are numerous holes in this pavement and many indications of either looseness of structure in the material itself or else of wear of the surface, and this is principally in the center of the street. The eastern half of this street is rough and in such condition as indicates either materials of inferior quality to that in other portions of the street, or else very bad laying. During nearly whole time this pavement was in hand the weather was unusually wet and unfavorable, and this may in a degree account for its condition.

Table showing the various asphalts which have been laid within the city of London, April, 1873—Continued.

Name.	Date.	Total carriage traffic from 8 a. m. to 8 p. m.	Area.	First cost of pavement, including foundation, per yard superficial.	Laying was completed.	Date of removal.	Time down.	Engineer's report.
Maestu asphalt (compressed blocks).			*Sup. yds.*	*s. d.*			*mo.*	
Threadneedle Street	July 20, 1871	3,538	281	12 0	Dec. 11, 1871	Jan. 26, 1872	1½	This pavement was laid upon inferior concrete; it was repaired once, but was ultimately removed about 1½ months from time it was put down. It was replaced with the Val de Travers compressed asphalt.
Trinidad asphalt (compressed).								
Princes street (south end, next to Mansion House street).	Feb. 15, 1872	5,628	340	10 8	June 19, 1872	Nov. 16, 1872	5	This pavement showed signs of wear directly it was opened to the traffic; it was repaired continually, but cut to pieces, and it was removed at the end of 5 months. It was replaced with Val de Travers compressed asphalt.
Patent British asphalt (mastic).								
Princes street	Feb. 15, 1872	5,628	371	12 0	July 6, 1872	Dec. 22, 1872	5½	This showed signs of wear soon after it was used. The traffic pulverized it; it was extensively repaired, but was removed at the end of 5½ months. It was replaced with Val de Travers compressed asphalt.

APRIL 18, 1873.

WILLIAM HAYWOOD.

WOOD AND ASPHALT PAVEMENTS IN LONDON.

SEWERS OFFICE,
Guildhall, March 17, 1874.

To the Honorable the COMMISSIONERS OF SEWERS OF THE CITY OF LONDON.

GENTLEMEN: The reference to me upon this subject is as follows:

"To report fully as to the relative advantages of wood and asphalt for paving purposes, together with the probable expense and durability of each."

I beg in the first place to lay before the commission some information respecting the wood and asphalt carriage-way pavements laid up to the present time in the city.

Wood.—The first wood pavement was laid in the Old Bailey in 1839, and was quickly followed by many others; they were of considerable variety, some being simple in structure, others very complicated, and none of them lasted more than 7 years. The streets were then not cleansed as well as they now are, which was disadvantageous to the wood, nor was the mode of preserving the surface of the wood well understood. Experience in the cost of pavements was almost entirely confined to those formed of granite, of a superior quality to that which now comes to London, and of stones more than double the size of those now generally used; and as the duration of some of the wood pavements was so small, and their cost much larger than granite, a prejudice appears to have arisen against wood, and the pavements as they wore out were for the most part replaced with granite.

Wood was, however, retained in Mincing Lane, Gracechurch street, Cornhill, Lombard street, Bartholomew Lane, Lothbury, and in part of the Old Bailey, until within the last 3 years, when, with the exception of that in Bartholomew Lane, it was replaced with asphalt.

The wood pavements more recently laid, and existing in the city thoroughfares at the end of 1873, with other information respecting them, are shown by the following table:

TABLE NO. 1.—*Table showing the lengths and areas of the different wood pavements in the city of London on December* 31, 1873.

Pavement.	Length.	Superficial area.
	Yards.	*Yards.*
Carey's	134	946
Improved wood	701	9,545
Ligno-mineral	27	410
Mowlem's	171	1,053
Stone's	26	284
Total	1,059	12,238

Asphalt.—The first pavement was laid in Threadneedle street in May, 1869, and was formed of the compressed asphalt of the Val de Travers company. Cheapside and the Poultry were laid with similar asphalt in the autumn of 1870, and many thoroughfares have since been paved with it and asphalts of other kinds. Those in the city thoroughfares at the end of 1873, with other information respecting them, are shown by the following table:

TABLE No. 2.—*Table showing the lengths and areas of the different asphalt carriage-way pavements in the city of London on December* 31, 1873.

Pavement.	Length.	Superficial area.
	Yards.	*Yards.*
Val de Travers (compressed)	4,185	34,876
Val de Travers (mastic)	69	232
Limmer (mastic)	1,446	8,477
Barnett's (mastic)	1,705	16,544
Société Française (compressed)	39	327
Montrotier (compressed)	40	346
Total	7,484	60,802

No two pavements, whether of asphalt or wood, are exactly similar in their qualities, nor will they be of the same durability or cost. It may be necessary specially to refer to some, although for the most part the remarks in this report will be applicable to asphalt and wood generally. Nevertheless, as it is needful to make direct comparison upon some points, I select for that purpose the compressed asphalt pavement of the Val de Travers Company, and the improved wood pavement, as being the best examples of their several kinds, and of which there are the largest quantities now laid in the city, and elsewhere in the metropolis. The following is a brief description of them:

The compressed asphalt pavement of the Val de Travers Company is formed of a natural material, procured from a mine in Switzerland; it is laid upon a bed of cement concrete, in a state of heated powder, and so as to be, when compressed, from 2 to 2½ inches in thickness, according to the traffic of the street.

The improved wood pavement is formed of fir blocks, 3½ inches wide, 10 inches long, and 6 inches deep, laid upon a foundation of two thicknesses of fir planks, well pitched and nailed together; the blocks are placed close together at their short ends, but on their longer sides are joints, running from side to side of the street, three-fourths of an inch wide, the lines of joint being kept by fillets nailed to the planks; the joints are filled up with clean small pebbles, rammed in, and then run with a composition formed of pitch, tar, or other bituminous substances.

It may be observed with regard to asphalt, that although there is much larger experience in its use than there was in 1871, when I reported upon the comparative merits of asphalt and granite pavements, I see no reason upon most points materially to alter the views and opinions therein expressed, and much then said will be repeated in the present report.

I take up the consideration under the same heads adopted in the report of 1871 upon granite and asphalt, varying only slightly their order, which will here be: (1) Convenience; (2) Cleansing; (3) Construction and Repair; (4) Safety; (5) Durability and Cost.

CONVENIENCE.

The principal, if not the sole object in London of employing either asphalt or wood for carriage-way pavements is to diminish the noise of the traffic.

Asphalt is less noisy than granite, for, being smooth and without joints, the wheels of vehicles run almost as easily over it as they do on a street tramway, and what noise is caused by the traffic comes almost entirely from the clatter of the horses' feet upon the asphalt.

Wood is less noisy than asphalt, the horses' feet making no clatter upon it; in fact, wood makes the most quiet of all known pavements.

Asphalt can not be suffered to get materially out of repair, for if it does it is speedily knocked to pieces, therefore, the quietness and the comfort it affords will be at all times nearly the same.

Wood pavements being composed of blocks of different sizes and jointed in different manners, are in the course of time worn into inequalities of surface, and when in that condition carriages are more jolted and there is more noise than when the pavements are new, but this is principally experienced by those inside the carriages.

The extent to which this irregularity of surface takes place depends much upon the care taken in its maintenance, but also upon the nature of the pavements; those formed of large blocks with wide joints wear more unevenly than those of small blocks with close joints. The owners contend that their improved wood pavement, having no short joints, and the blocks reposing upon a slightly elastic foundation, will not wear unevenly, and probably it will wear more evenly and last longer than any other wood pavement yet laid, but it certainly will wear somewhat round in the direction of the traffic.

There is a rumbling noise noticeable when inside a carriage driven quickly over this pavement which I never observed upon others, and is thought by some to be disagreeable. The cause is probably owing to the compactness of its structure, its extreme regularity of surface, and the elasticity of the foundation. Should the extreme regularity of surface disappear the noise will, I think, diminish. This noise, however, only affects those inside vehicles; in other respects it is as quiet as other wood pavements.

Pedestrains, where the carriage traffic admits of it, walk largely upon asphalt, owing to its smoothnoss, cleanliness, and dryness. As far as I have observed, they do not walk so much upon the wood.

Asphalt being impervious to moisture, water runs off it quickly or is soon evaporated. Dirt lingers in the joints of wood pavements and is worked out by the traffic, making the surface dirty for some time after rain. Where carriageways are dry and clean the footways are usually clean, for in narrow streets of much traffic most of the dirt upon the footways comes from the carriageways. The relative advantages of the two pavements in this respect depend, however, largely upon the care taken in cleaning.

Wood absorbs moisture and is frequently damp when asphalt is dry; but if it be reasonably clean, the dampness does not affect the safety or comfort of the traffic. When dry weather ensues after rain, dirt clings to the wood, and there is no dust for some time.

It has been said that wood pavements at times smell offensively, and may be unhealthy; but although some city streets have been paved with wood for 30 years, no complaints that I am aware of have been made to the commision on this head, and the inhabitants at all times have not only expressed great anxiety lest the wood should be replaced by other material, but have subscribed toward the cost of its renewal. In the northern towns of Europe wood pavement is much used. In America and Canada many of the largest cities are paved almost entirely with wood, and it is not there believed to be unhealthy. I have at times noticed offensive emanations from it near cab stands, but am unable to find other evidence of its unhealthiness. These remarks must be held to apply only to public streets open to sun, air, and traffic; in confined places, and under some conditions, wood might be objectionable. I have seen it decaying in confined places without traffic.

It may be desirable to refer to the question whether wood pavements are likely to be the means of spreading a conflagration. It was found by experiments made by me for the commission, in conjunction with Captain Shaw, chief officer of the fire brigade, that asphalt, subject to a more severe test than it would be in the case of an ordinary fire, would not aid in spreading a conflagration, and there is no reason to suppose that wood would be more likely to do so, laid, as it is, under conditions rendering surface ignition improbable. At Chicago the foot pavements were, in many cases, formed of planks laid on wooden joists, the whole structure being 1 or 2 feet above the carriageway, and subject to the action of the fire on both sides, but it is doubtful whether the fire was materially, if at all, increased by those footway pavements.

Asphalt and wood have therefore each in some respects advantages which the other does not possess in an equal degree. On the average of its life asphalt is the smoothest, the dryest, the cleanest, the most pleasing to the eye, and on the whole the most pleasant to travel over (apart from the question of safety), but in respect of quietness to the inhabitants and street traffic wood is superior to asphalt.

CLEANING.

Both asphalt and wood should be kept very clean for safety, but great cleanliness is more important to asphalt than it is to wood.

Asphalt can be kept cleaner than any other pavement, for, being nonabsorbent and without joints, the broom, the scraper, the shovel, or water can be applied to it most effectively. Wood pavements are most difficult to clean on account of the joints and the absorbent nature of the material. The Improved Wood Pavement Company has recently kept the carriageways of King William street and Ludgate Hill (temporarily committed to their charge) in a state of cleanliness never before attained on wood. The cost of this work I am unable to state.

Experiments made under my direction in 1867 and in 1873 in washing granite and asphalt with jet and hose showed that asphalt cost slightly less than granite, but that a higher state of cleanliness can be obtained on it. It is probable that the cost of washing wood would also be more than that of asphalt. Washing is the best way of cleansing all pavements, and it is desirable that an experiment be made on wood at an early opportunity.

The moisture left on the surface of asphalt by washing makes it slippery, the duration of the slipperiness depending upon the care taken in drying it and on atmospheric conditions. Moisture does not leave wood slippery if it be clean. Moisture, although visible, is frequently rather in the wood than on its surface, a fact to be held in mind when considering this point.

Watering to lay the dust on asphalt is not done in the city, much care being taken to keep the pavements clean by constant removals of the refuse. Statements have been made that a fine dust arises from it which is obnoxious to traders having fine goods, but some dust is unavoidable in streets of great commerce and traffic, whatever may be the pavement or the mode of cleansing adopted. Watering asphalt is objectionable on account of the temporary slipperiness it creates, and as the surface soon dries at the season of the year when there is the most dust, watering, to be useful, should be almost continuous.

Wood pavements as at present cleansed require watering, for dirt clings to them more than to the asphalt. If washed daily and the street-orderly system be employed during the day, it is just possible watering might be dispensed with, but I am by no means sure of that.

Asphalt, when laid or repaired, is fit for the traffic a few hours afterward; it is left clean and causes no inconvenience from dirt or dust.

Wood, when newly laid or when repaired, is covered with fine gravel or grit of some sort, which should lie upon it some days. This grit being pressed into it by the traffic, indurates and preserves the surface. For the same reason it is desirable several times a year to strew the surface for a day or two in a similar manner, and at those times the pavement is dirty. It is not, as a rule, necessary to strew wood with gravel to prevent slipperiness, although there are occasions when it is useful to do so. With present experience it is necessary to strew asphalt with sand when the surface is slightly damp and there is much traffic in the street.

Upon the whole I consider that wood may be kept cleaner than it hitherto has been, but that whatever be the process adopted it will be more difficult and expensive to keep clean than asphalt that the moisture from watering, which leaves asphalt slippery, affects wood less objectionably (as will be seen when the question of safety is dealt with); that there is necessity upon occasions for strewing the surfaces both of asphalt and wood with sand or gravel; that the sanding of asphalt

must be more frequent than the graveling of wood; that the graveling of wood for the time renders the streets more dirty than the sanding of asphalt does, but that the degree of inconvenience from both these operations depends upon the care with which they are performed.

CONSTRUCTION AND REPAIR.

Cheapside and the Poultry were laid with compressed asphalt, together with the concrete foundation, at the rate of 129 yards per day; Ludgate Hill was laid with the improved wood pavement, including the removal of earth for the plank foundation, at the rate of 125 yards per day; other wood and asphalt pavements can be laid as expeditiously. These remarks apply to fine weather. In wet weather neither the concrete foundation nor the asphalt can be laid. Wood blocks, if not requiring a concrete foundation, can be laid in most weathers, but the grouting of the joints, whether with lime or asphalt, can not be properly done unless the weather be reasonably dry. The same remarks apply to repairs both to asphalt and wood in respect to weather.

Very small surface repairs can be made with facility in all asphalts. In compressed asphalt they can be made so neatly as not to be noticeable after a short time but in the mastic asphalts the joints remain visible.

The ease with which repairs can be made to a wood pavement depends upon it, character. Ordinarily they can be done with the same facility, and are executed in much the same manner as to granite. Repairs to the improved wood pavement are differently performed and require some descr iption. The plank foundation is cu through, the line of cut in the two layers being at different places; a third board is then first laid beneath the lowest planking so as to break the joint; the two layers of planking are then relaid and spiked together, the fillets and blocks being replaced and grouted in the usual manner. Although the continuity of the original planks is thus destroyed the repair seems to be done with ease, and as far as experience goes is sufficient for all practical purposes; but I think the repairs take a somewhat longer time than the ordinary wood pavements.

Repairs have been made over pipe trenches in King William street, Great Tower street, and Bartholomew lane, the surface in all cases has been well restored, and the work was done quickly. This pavement is referred to at some length, it being in structure different from any others yet laid in the city, and, therefore, needing explanation.

Taking seasons and weather generally into account, asphalt and wood can be laid and repaired with equal expedition, but repairs to wood pavements generally are not so permanent as those to asphalts, usually also it is necessary to take up a much larger surface in wood to make a good repair than it is in asphalt, which can be cut out to the exact size needed. In this respect asphalt has a decided superiority over wood

SAFETY.

The safety of a pavement is a matter of importance everywhere, but especially so in narrow thoroughfares of great traffic, where accidents also cause inconvenience to the general traffic.

Observations made at Paris some years ago in two streets, one paved with the hard sandstone, much used in that capital, and the other with asphalt, showed that in the street paved with stone one out of every 1,308 horses fell, and in that paved with asphalt one out of every 1,409 horses fell.

The city police in 1871 made observations, from which it was found that about six horses fell daily in the length of Cheapside and the Poultry, or at the rate of one out of every 2,323 passing along those thoroughfares. The same year I made inquiries into the slipperiness of asphalt, and took the opinions of various persons who from their occupations had special opportunities for forming correct judgment upon the

point, and on consideration of the information then obtained there appeared to be good reason for believing that on the average of the year asphalt was not more slippery than granite.

There were, however, at that time but two or three streets paved with asphalt, and alternate routes paved with other material were open to the traffic. Complaints of the slipperiness of asphalt have increased since its use has been extended, and although allowance must be made for the prejudice which generally exists against any new class of pavement (there was a time when loud complaints were made of wood being much more slippery and dangerous than granite), some of the statements made to the commission are entitled to consideration.

Among them was a petition presented in July last signed by twenty-four horse owners, including the London General Omnibus Company, two of the largest English carriers, the managers of three railways, and cab and omnibus proprietors. Sixteen of the petitioners stated that they owned amongst them 13,448 horses, of which the London General Omnibus Company owned 8,000; the remaining fifteen owned 5,448, or an average of 363 horses each. The petitioners, after stating that in their opinion asphalt pavement was objectionable as compared with granite, and that horses were quickly deteriorated by traveling over it, prayed the commission "that no more of such paving shall be laid down in the principal thoroughfares," and further, "that effective measures should be taken to render the asphalt pavement now existing less dangerous to horses in damp weather."

To obtain exact information on the point the commission in the spring of last year directed observations to be made of the accidents occurring upon asphalt, granite, and wood pavements. These observations (the most extensive, I believe, ever made) were taken by the city police and reported on by me on the 16th December last; to that report it will be now necessary to refer.

The streets selected for observation were: Cheapside and the Poultry, paved with compressed asphalt of the Val de Travers Company; part of King William street and Gracechurch street, paved with the improved wood pavement and the ligno-mineral pavement, and parts of King William street and Cannon street, paved with 3 inch Aberdeen granite. All the streets had a large and varied traffic. The observations were continued for 50 days of 12 hours daily, and represented an aggregate distance traveled by the horses of 478,523 miles.

The observations on asphalt and wood are alone dealt with here. Both pavements were in excellent surface condition; on both the gradients were for the most part good, those of the wood being the worst; both were cleansed every morning and also throughout the day by street orderlies. The asphalt was occasionally washed, and when damp strewed with sand. The wood pavement was four times slightly strewed with fine gravel. The asphalt was not watered to lay the dust; the wood was. The aggregate distance traveled by the horses during the observations was, on the asphalt 203,805 miles, and on the wood 179,151 miles, making together 382,956 miles.

During the 50 days' observations the weather was for the most part dry and cold. There was an absence of that weather which, creating a damp surface, causes asphalt to be in its most slippery state. The weather was also decidedly favorable to wood. On the whole it may be said that the two pavements were under conditions as nearly similar as are likely to be obtained unless a street be specially selected and paved for the purpose of observations.

A short length of the wood was the ligno-mineral pavement, formed of beech, mineralized, the blocks being of small size, with chamfered edges. The accidents upon this pavement were very much greater proportionally than those on the other wood, a circumstance probably due mainly to the description of the wood, and to its chemical treatment. Fir is almost exclusively used in the formation of wood pavements, but the accidents which took place on the ligno-mineral are included in all the averages given of accidents and mileage.

On the average of the 50 days' observations it was shown that a horse might be expected to travel before it fell—

	Miles.
On the asphalt	191
On the wood	330

The accidents were afterwards separated under three heads, namely, those which occurred when the pavements were dry, those which occurred when they were damp, as during or after a slight rain and after the streets had been watered, and those which took place whilst rain was falling, or whilst the surfaces were quite wet, and the following results were shown:

	Miles.
Days when surface of pavement was generally dry:	
Asphalt	223
Wood	646
Days when surface of pavement was damp in different degrees, including that arising from surface watering:	
Asphalt	125
Wood	193
Days when surface of pavement was wet:	Miles.
Asphalt	192
Wood	432

Thus, under every condition of surface moisture, and including nearly every condition of weather, frost excepted, the wood was less slippery than the asphalt.

For 32 days the accidents were recorded under the respective heads of falls on knees, falls on haunches, and complete falls, with the following results:

TABLE NO. 3.

	Accidents during 32 days' observations.		
	On knees.	On haunches.	Complete.
	Per cent.	*Per cent.*	*Per cent.*
Asphalt	32.04	24.48	43.48
Wood	84.97	3.07	11.96

Accidents which are the least inconvenient to the traffic and the least injurious to horses are falls on knees, the next in order are falls on haunches, complete falls are the worst of all; and the table shows therefore that in this respect wood was superior to asphalt, the largest proportion of falls on it being on knees.

It is by some considered that the only accidents of importance, or that need be referred to when the safety of a pavement is under consideration, are complete falls. Adopting for the time this view, dismissing the other classes of accidents, and making the calculations in reference to complete falls only, the results of the 32 days' observations were that a horse might be expected to travel before it fell down on its side—

	Miles.
On the asphalt	686
On the wood	2,939

Extending the comparison by distributing complete falls only to the miles traveled, under different conditions of surface as regards moisture, the results were:

	Miles.
Days when the surface of pavement was generally dry:	
Asphalt	1,101
Wood	4,180

Days when surface of pavement was damp in different degrees, including that arising from surface watering:

	Miles.
Asphalt	335
Wood	1,592

Days when the surface of pavement was wet:

Asphalt	568
Wood	3,583

Thus, the obervations show conclusively the wood to be safer than asphalt, and the accidents on it to be of a less objectionable character.

Mastic and compound asphalts are somewhat less slippery to the human foot than compressed asphalts. How far the difference is perceptible to horses, shod as they are, I can not say, but that which causes this superiority in respect of slipperiness leads to their being more speedily worn out under heavy traffic. There are wood pavements more slippery than the improved wood pavement, which is, perhaps, the least slippery of its class; and had it been out of repair, more accidents, proportionately, would have occurred upon it than actually took place, and all wood pavements get out of repair in time. But whatever asphalt or wood (fir being only meant) had been selected for comparison, there is no reason to believe that the relative values of the two materials, as regards safety, would have been reversed, and for comparison it was, of course, necessary to take the two which are the best representatives of their classes for the general purposes of street traffic.

Slight rain makes both asphalt and wood more slippery than it is at other times. On asphalt the slipperiness begins almost immediately the rain commences; wood requires more rain before its worst condition ensues. The slipperiness lasts longer upon the wood, on account of its absorbent nature, than it does upon the asphalt when dry weather ensues after the rain.

When asphalt is in its most slippery state the horses at times fall on it very suddenly; on wood their efforts to save themselves are more effectual. Wood also is frequently in that peculiar condition of surface in which horses slip or glide along it without falling. A small quantity of dirt on asphalt makes it very slippery; wood requires a large quantity. These are general statements, subject to modifications, according to the nature of the wood or asphalt, their condition of repair, and cleanliness.

Slipperiness can be temporarily cured on both pavements, on the asphalt by sprinkling it with sand, on the wood by sprinkling it with gravel. The result in both cases is dirt. The difficulty of cleaning wood as compared with asphalt has already been referred to. The sand thrown on asphalt helps to wear it out; the gravel thrown on wood tends to preserve it. Watering or washing asphalt to prevent slipperiness has been tried, and no doubt for the time cures it, but sloppy streets are a great nuisance, and not likely to be submitted to. Sand must, with present experience, be the remedy, and when applied is certainly effectual. Sanding is the remedy applied at Paris.

When a horse falls upon asphalt, it has difficulty in getting up. On wood it rises more easily. The difficulty in rising from asphalt can, however, be largely remedied by throwing down a little sand, or a horse-cloth, a care which does not often seem to be bestowed by the drivers.

The effect of frost must be referred to. In times of snow there is but little, if any, difference between the safety of asphalt and wood. In times of sharp frost asphalt is usually dry and safe; wood retaining moisture is very slippery. The effects of frost on pavements in the heart of London should not, however, have undue weight in these considerations, two or three winters sometimes passing without snow lying for an entire day in the city streets, or frost rendering the surface of any pavement slippery for more than a few hours at a time. The cure for slipperiness in all cases is sanding or graveling.

As regards speed of travel.—When asphalt is dry and the road unimpeded, vehicles can be driven over it as quickly and as safely as on other pavements, but in streets of much traffic it is not wise to drive quickly because of the difficulty of stopping a horse; on wood it is easier to stop a horse, times of frost excepted.

As to gradient.—A short length of asphalt in the city has a gradient of 1 in 46, another 1 in 57; nearly the whole length has much better gradients. The commission in 1871 determined not to lay asphalt upon a steeper gradient than 1 in 60, and it is a safe gradient at which to draw the line.

The two wood pavements in Bartholomew lane (Carey's, and the improved wood) have gradients of 1 in 34; in King William street there are gradients of from 1 in 30 to 1 in 37, with cross gradients at the same spots of from 1 in 20 to 1 in 38; part of Ludgate Hill has a gradient of 1 in 26, and all these are safe. Wood, therefore, can be laid with safety at a far steeper gradient than asphalt.

Generally, therefore, whether the question of safety be considered in reference to the distance which a horse may travel before it meets with an accident, or the nature of the accidents which occur, the facility with which a horse can recover itself when it falls, the speed at which it is safe to travel, or the gradient at which the material can be laid, wood is superior to asphalt.

DURABILITY AND COST.

Durability is an element in the cost of all pavements, and it is desirable therefore in the first place to see what has hitherto been the life of asphalt and wood in carriage ways.

Asphalt.—Experience in London in the use of asphalt for carriageway pavements dates from May, 1869; at the end of 1870 there were but 3 streets paved with it in the city, the great bulk of the work having been done in the last 3 years. During that time eleven different sorts have been tried, five of which have failed, and there are others in an unsatisfactory condition, some showing unmistakable signs of decay, and the necessity for a not far distant renewal or extensive reparation. Compressed asphalts have hitherto proved themselves the most durable; those which had been the longest down were examined carefully last year, and the loss on them by wear found to be small, and they were generally in good surface condition.

At Paris it has been used longer and more extensively than in any other city, the first street having been laid with it in 1854. In most of the streets so paved the traffic is small, but there are some, such as the Rue de Richelieu and the Rue Neuve St. Augustin, in which it is considerable. I have been unable to ascertain the actual life of the pavements at Paris, for the system adopted is to repair them immediately they need it, and as each repair is so much new material laid, the whole surface is really renewed in the course of years. The same system is and must be adopted in London. Statements given to me by the companies of the extent of repair done to the various pavements since they were laid do not well agree with my own observations, and the payments agreed to be made for maintaining the pavements must be based upon the assumption of considerable renewal of surface being needed. After full consideration of all circumstances, I think that without much repair none of the asphalts would last more than from 4 to 6 years, and that in the course of from 6 to 10 years the entire surface of all will have been renewed.

There not being, however, sufficient experience to determine the durability of asphalt in this city, all that can be done is to take the contracts entered into for maintaining the pavements as giving both the measure of their life and their cost. This mode was taken in the comparison between the cost of asphalt and granite in my report of 1871. The following table gives the agreed costs of asphalt in some leading thoroughfares:

Table No. 4.—*Asphalt pavements.—Table showing the agreed cost per annum of certain asphalt carriage-way pavements in the city of London.*

Situation.	Description of asphalt.	Years to be maintained by contractors.	First cost per square yard.		Agreed cost of maintenance per square yard for the contract term.	Total cost of pavements during contract term per square yard.			Average cost per square yard per annum.	
			s.	*d.*		£	*s.*	*d.*	*s.*	*d.*
Cheapside and Poultry.	Val de Travers (compressed).	17	18	0	2 years free; 15 years at 1*s.* 6*d.* = £1 2*s.* 6*d.*	2	0	6	2	4½
Gracechurch street	....do	17	17	0	2 years free; 15 years at 1*s.* 0*d.*=15*s.* 0*d.*	1	12	0	1	10½
Finsbury pavement	....do	17	16	0	2 years free; 15 years at 9*d.*=11*s.* 3*d.*	1	7	3	1	7¼
Moorgate street ...	....do	17	16	0	2 years free; 15 years at 9*d.*=11*s.* 3*d.*	1	7	3	1	7¼
Do............	Limmer (mastic)..	17	16	0	2 years free, 15 years at 9*d.*=11*s.* 3*d.*	1	7	3	1	7¼
Lombard street....	....do	17	16	0	2 years free; 15 years at 9*d.*=11*s.* 3*d.*	1	7	3	1	7¼
Cornhill	....do	17	15	0	2 years free: 15 years at 9*d.*=11*s.* 3*d.*	1	6	3	1	6½
Mincing lane	....do	17	12	0	2 years free; 15 years at 9*d.*=11*s.* 3*d.*	1	3	3	1	4½

Foundations are included in these estimates, but no excavation. The pavements are to be left as good as new at the expiration of the contracts.

Wood.—Counting size of block as constituting a difference, there must have been more than two dozen different kinds of wood pavements tried in the city. They have been laid in streets both of large and small traffic, and subjected to almost every condition which destroys a pavement. The commission has, therefore, experience of its own both in the durability and the cost of wood.

Last year a report was obtained by the commission from New York respecting the wood pavements in that city, from which it appeared that its average duration did not exceed 5 years. The information is not, however, of that precise character which would make it of use for comparison here; and the climatic conditions at New York are so different to those in London that it might be but of little use even if the information were fuller, for climate affects the safety, durability, and other conditions of both asphalt and wood, and as there is large experience in wood pavement in this metropolis I confine myself to that experience.

The table appended shows the duration and cost of wood pavements in six city thoroughfares, all the pavements having been replaced by asphalt except one.

Table No. 5.—*Wood pavements—Table showing the actual duration and cost of certain wood pavements in the city of London.*

Situation.	Date when laid new.	Life.		First cost per square yard.		Total cost of repairs per square yard during life.			Average cost per square yard per annum.	
		Yrs.	*Ms.*	*s.*	*d.*	£	*s.*	*d.*	*s.*	*d.*
Cornhill........................	May, 1855	10	2	12	2		17	4½	2	11
	July, 1865	6	8	11	6		9	9¾	3	0¼
Gracechurch street	Nov., 1853	11	7	12	8		17	1½	2	6¾
	June, 1865	6	0	11	6		6	11	3	0¾
Lombard street	May, 1851	9	4	9	6		6	0	1	7¾
	Sept., 1860	10	7	9	2	1	0	2	2	9
Lothbury	May, 1854	12	3	12	6	1	8	4¾	3	4
	Aug., 1866	6	1	12	6		3	5¾	2	7⅛
Mincing lane..................	July, 1841	19	1	14	4		13	4	1	5½
	Aug., 1860	13	0	9	2	1	2	6¾	3	5¼
Bartholomew lane..............	May, 1854	12	3	12	6		17	5¾	2	5¼
	Aug., 1866	5	5	12	6		3	11½	3	0¼

Foundations are included, but no excavation.

The average life of the pavements in the three streets with the largest traffic was about 9 years, that of the three streets with the least traffic about 11½ years.

Nearly all before they were removed had been relaid over their entire surface and some new wood introduced from time to time in lieu of that found too defective to relay.

It will be observed that the wood pavements last removed had a shorter life than the previous pavements. There is more than one reason for this, but it should be stated that nearly all would, by relay and the introduction of some new wood, have endured a few years longer. It was, however, thought by the commission expedient to replace them with asphalt, with the exception of that in Bartholomew lane.

The mean of the three streets of largest traffic gives a cost of 2*s.* 7½*d.* per square yard per annum; the mean of the streets of little traffic a cost of 2*s.* 4¼*d.* per square yard per annum. The cost of the wood pavements which have been removed has, therefore, been higher than the cost of asphalt will be under the existing contracts.

In a previous report I have stated that much of the expense of granite pavements in the city is attributable to their being too much patched and not being relaid over their whole surface at sufficiently early periods. (There were reasons given why this is the case.) The same remarks, in a degree, apply to wood, the blocks of which are not so convertible, nor as a refuse material so valuable as old granite. If they were relaid when it was best for the pavement and most economical to do so, their duration would be increased and their cost diminished.

Under present contracts both the wood and asphalt contractors must be permitted to relay and repair the pavements when it will be best to do such work, and for comparison it is therefore better to take the tendered prices for the wood pavements recently laid as the measure of their life and cost, contrasting them with the tendered prices for maintaining the asphalt. The comparison is not expensive, the commission having in some cases accepted tenders involving the maintenance of wood pavements for short terms only.

TABLE No. 6.—*Wood pavements—Table showing first cost and tendered cost per annum for maintaining certain wood carriageway pavements in the city of London.*

Situation.	Date when laid.	Name of contractor.	Years to be maintained by contractor.	First cost per square yard.	Agreed cost of maintenance per square yard for contract term.	Total cost during contract term, per square yard.	Average cost per square yard per annum.
				s. d.		*£ s. d.*	*s. d.*
King William street.	Feb., 1873	Improved Wood Paving Co.	16	18 0	1 year free; 15 years, at 1*s.*6*d.* = £1 2*s.* 6*d.*	2 0 6	2 6¼
Ludgate Hill......	Nov., 1873	....do.........	16	18 0	1 year free; 15 years, at 1*s.*6*d.* = £1 2*s.* 6*d.*	2 0 6	2 6¼
Portions of Great Tower street and Seething Lane.	Sept., 1873	....do.........	16	16 0	1 year free; 15 years, at 1*s.*3*d.* = 18*s.* 9*d.*	1 14 9	2 2
Bartholomew lane.	Jan., 1873	Carey.........	(*)	12 6	....	....	....
Do	Dec., 1871	Improved Wood Paving Co.	†3	16 0	3 years free.......	16 0	....
Duke street.......	May, 1873	Mowlem & Co.	†‡5	15 3	2 years free; 3 years, at 1*s*=3*s.*	....	....
Houndsditch......	(§)	....do.........	†‡7	17 0	2 years free; 5 years, at 9*d.* = 3*s.* 9*d.*	....	....
Do	...do	Carey.........	†‡7	13 6	2 years free; 5 years, at 1*s.* = 5*s.*	....	....

* No agreement.

† These pavements will no doubt last some years longer than the contract term of maintenance.

‡ The Ligno-Mineral Paving Company and the Improved Wood Paving Company offered to maintain their pavements, if laid, for terms of 10 years and 14 years, respectively; their tenders were not accepted.

§ Not yet laid.

In the wood pavements the cost of the foundation is included, but not excavation.

The pavements at the end of each financial year are to be in a good sound condition.

The following table is drawn up from tables Nos. 4 and 6:

-TABLE NO. 7.—*Table showing the duration and cost of certain asphalt and wood carriageway pavements, according to tenders made by the respective contractors.*

Situation.	Description.	Years to be maintained by contractor.	Average cost per square yard per annum.
Asphalt:			*s.* *d.*
Cheapside and Poultry	Val de Travers (compressed).	17	2 4½
Gracechurch street	....do	17	1 10½
Finsbury pavement	....do	17	1 7¼
Lombard street	Limmer (mastic)	•17	1 7¼
Cornhill	....do	17	1 6½
Wood:			
King William street	Improved wood	16	2 6¼
Ludgate Hill	....do	16	2 6¼
Portion of Great Tower street and Seething lane.	....do	16	2 2

Pavements cost more or less according to the width and traffic of the streets; exact comparison is, therefore, unattainable, but from tables Nos. 4, 6, and 7 it appears generally that the improved wood pavement will be dearer than compressed asphalt, and still dearer if contrasted with limmer. There are other asphalt and wood pavements nominally cheaper, but it is expedient to keep to the best of the two classes for comparison.

CONCLUSIONS.

My general conclusions upon the subject matter of the report are:

Firstly, as regards convenience: That asphalt is the smoothest, driest, cleanest, most pleasing to the eye, and most agreeable pavement for general purposes, but wood the most quiet.

Secondly, as regards cleansing: That wood may be kept cleaner than it hitherto has been, but will be more difficult and expensive to cleanse effectually than asphalt; that as both pavements require occasionally strewing either with sand or gravel, there is not much difference between them in that respect.

Thirdly, as regards construction and repair: That asphalt and wood, taking all seasons and weathers into account, can be laid and repaired with about equal facility, but that the smallest, neatest, cleanest, and most durable repairs can be made in asphalt.

Fourthly, as regards safety: That whether considered in reference to the distance which a horse may travel before it meets with an accident, or the nature of the accident, or the facility with which a horse can recover its footing, or the speed at which it is safe to travel, or the gradient at which the material can be laid, wood is superior to asphalt.

Fifthly, as regards durability and cost: That wood pavements, with repairs, have in this city had a life varying from 6 to 19 years, and that with repairs an average life of about 10 years may be obtained; that the durability of the asphalts is not known, but that under the system of maintenance adopted they may last as long as wood; that contrasting the tenders for laying and maintaining for a term of years the two best pavements of their kinds, wood will be the dearest.

To avoid misapprehension it may be well again to state that these remarks apply, in most cases, to asphalt and wood pavements generally, but are more strictly applicable to the compressed asphalt of the Val de Travers Company and to the improved wood pavement. Also that they apply to streets of much traffic and in London, for where the climate and other conditions are widely different, different results, as regards safety and cost, etc., may be expected.

I have the honor to remain, gentlemen, your most obedient servant,

WILLIAM HAYWOOD,
Engineer and Surveyor.

TABLE No. 8.—*Wood pavements.—Table showing the situation, description, area, and date of completion of the wood pavements in the city of London.*

Situation.	Name of pavement.	Length.	Superficial area.	When completed.	Description of pavement.
		Yards.	*Yards.*		
Bartholomew lane.	Carey's wood pavement.	40	468	Jan., 1872	Fine ballast foundation; paving blocks varying in width from 6½ in. to 7½ in., and in length from 13 in. to 15 in., 6 in. deep; ⅜-in. longitudinal and ¾-in. transverse joints, grouted with lime and sand.
Birchin lane	....do	28	77	June, 1866	Do.
Jewry street	....do	42	253	Feb., 1872	Do.
Little George street	....do	24	148	....do	Do.
Bartholomew lane.	Improved wood pavement.	48	392	Dec., 1871	Plank foundation; blocks 3 in. by 9 in., 5 in. deep; ¾-in. transverse joints filled in with pebbles and tar or other bituminous substances.
Great Tower street and Seething lane.	....do	76	448	Aug. 4, 1873	Plank foundation; blocks 3 in. by 9 in., 6 in. deep; ¾-in. transverse joints filled in with pebbles and tar or other bituminous substances.
King William street, from Gracechurch street and Cannon street to Arthur street.	....do	164	3,446	Aug. 13, 1872	Plank foundation; blocks 3½ in. by 10 in., 6 in. deep; ¾-in. transverse joints filled in with pebbles and tar or other bituminous substances.
King William street (south of Arthur street) and Adelaide place.	....do	147	2,620	Jan. 25, 1873	Do.
Ludgate Hill	....do	266	2,639	Nov. 8, 1873	Do.
Gracechurch street.	Ligno-mineral pavement.	27	210	Aug., 1872	Concrete foundation; blocks 3½ in. by 6 in., 4½ in. deep; ends cut obliquely; ¼-in. joints, grouted with Portland cement.
Cannon street	Mowlem's wood pavement.	37	377	Sept. 5, 1873	Concrete foundation; blocks 3 in. by 9 in., 7 in. deep; ⅛-in. joints, grouted with lias lime and washed sand.
Duke street, Smithfield.	....do	134	676	June 7, 1873	Do.
King William street (north of Cannon street).	Stone's patent wood pavement.	26	284	July 15, 1873	Concrete foundation, with grooves in surface 1½ in. by ½ in., 3 in. apart; blocks 4 in. by 6 in., 4 in. deep; the bottoms shaped to fit in grooves; ½-in. transverse joints, filled in with tar composition.

WM. HAYWOOD.

MARCH 17, 1874.

TABLE No. 9.—*Asphalt pavements.—Table showing the situation, description, area, and date of completion of the asphalt pavements in the city of London.*

Situation.	Name of pavement.	Length.	Superficial area.	When completed.	Description of pavement.
		Yards.	*Yards.*		
Bow Lane, from Cannon street to Cheapside.	Val de Travers asphalt.	164	425	Sept. 22, 1873	Concrete foundation 6 in. thick; compressed asphalt 2 in. thick.
Cheapside and Poultry.	....do	625	7, 938	Dec. 9, 1870	Concrete foundation 9 in., asphalt 2¼ in.
Finsbury pavement and Moorgate.	....do	600	3, 861	Aug. 18, 1871	Concrete foundation 6 in., asphalt 2 in.
George yard, Lombard street.	....do	69	232	Apr. 1, 1871	Concrete foundation 6 in., mastic asphalt 1½ in.
Gracechurch street.	....do	272	2, 659	July 22, 1871	Concrete foundation 9 in., compressed asphalt 2½ in.
King William street (west end).	....do	135	1, 439	Nov. 12, 1873	Concrete foundation 6 in., compressed asphalt 2 in.
London wall from Moorgate to Old Broad street.	....do	400	3, 164	Oct. 18, 1871	Do.
Mansell street	....do	131	734	Oct. 22, 1871	Do.
Mansion House street.	....do	74	3, 043	June 21, 1872	Concrete foundation 6 in., compressed asphalt 2 in.
Milk street	....do	60	297	Mar. 22, 1871	Concrete foundation 9 in., compressed asphalt 2 in.
Moorgate street (north end).	....do	99	1, 027	Aug. 18, 1871	Do.
Old Bailey	....do	68	402	May 2, 1871	Do.
Old and New Broad streets.	....do	485	3, 671	Mar. 25, 1871	Do.
Queen street	....do	108	799	Apr. 27, 1871	Concrete foundation 9 in., compressed asphalt 2½ in.
Russia row	....do	33	80	Mar. 22, 1871	Concrete foundation 6 in., compressed asphalt 2 in.
St. Ann's lane	....do	68	452	Oct. 18, 1873	Do.
Threadneedle street (west end).	....do	47	485	June 5, 1869	Concrete foundation 8 in., compressed asphalt 2 in.; on mastic ½ in.
Threadneedle street (east end).	....do	113	438	Dec. 22, 1871	Concrete foundation 9 in., compressed asphalt 2 in.
Throgmorton street.	....do	43	150	Mar. 30, 1871	Concrete foundation 6 in., compressed asphalt 2 in.
Wood street, from London Wall to Gresham street.	....do	300	1, 492	Sept. 7, 1871	Do.
Wood street, from Gresham street to Cheapside.	....do	170	671	Sept. 13, 1873	Do.
Castle street, Holborn.	Limmer asphalt	163	567	Nov. 7, 1873	Concrete foundation 6 in., mastic asphalt 2 in.
Clement's lane	....do	129	443	Oct. 23, 1873	Do.
Cornhill	....do	331	3, 333	Mar. 6, 1872	Concrete foundation 6 in., mastic asphalt 2 in.
Finch lane	....do	87	227	Sept. 23, 1873	Concrete foundation 6 in., mastic asphalt 2 in.
Lombard street	....do	278	1, 153	May 18, 1871	Concrete foundation 9 in., mastic asphalt 2 in.
Mincing lane	....do	197	955	Aug. 23, 1873	Concrete foundation 6 in., mastic asphalt 2 in.
Moorgate street (central).	....do	105	1, 038	Sept. 6, 1871	Concrete foundation 9 in., mastic asphalt 2 in.
Old Jewry	....do	156	761	Oct. 18, 1873	Concrete foundation 6 in., mastic asphalt 2 in.
Bishopsgate street within.	Barnett's asphalt	409	4, 288	Dec. 21, 1872	Concrete foundation 9 in., mastic asphalt 2¼ in.
Carter lane, from Creed lane to Paul's Chain.	....do	153	757	Sept. 7, 1872	Do.
Fenchurch street	....do	463	3, 869	June 11, 1873	Do.
Leadenhall street	....do	485	4, 189	Apr. 11, 1873	Do.
Lothbury	....do	103	2, 384	Oct. 10, 1872	Do.
Moorgate street (south end).	....do	92	1, 057	Oct. 14, 1871	Do.
Princes street	Société Francaise des Asphaltes.	39	327	July 18, 1872	Concrete foundation 9 in., compressed asphalt 2½ in.
Do.	Montrotier asphalt.	40	346	Aug. 14, 1872	Concrete foundation 12 in., compressed asphalt 2 in.
Threadneedle street.*	Maest. asphalt	61	281	Jan. 26, 1872	Concrete foundation 9 in., asphalt 2 in.

* Removed January 26, 1872, and Val de Travers compressed asphalt laid in its place.

TABLE NO. 9.—*Asphalt pavements.—Table showing the situation, description, area, and date of completion of the asphalt pavements in the city of London*—Continued.

Situation.	Name of pavement.	Length.	Superficial area.	When completed.	Description of pavement.
		Yards.	*Yards.*		
Princes street*	Trinidad asphalt	29	340	June 19, 1872	Concrete foundation 9 in., asphalt 2 in.
Do.†	Patent British asphalt.	39	371	July 6, 1872	Do.
King William street.‡	Stone's slipless asphalt.	33	358	July 28, 1873	Concrete foundation 6 in. thick, asphalt 2½ in. thick, composed of tar, cement, sand, and lead ore, compressed by machinery.
Do.§	Foothold metallic asphalt.	28	299	Oct. 27, 1873	Concrete foundation 6 in. thick, asphalt 4 in. thick, viz, 3 in. of English upon 1 in. of foreign manufacture, fused together.

* Removed November 16, 1872, and Val de Travers compressed asphalt laid in its place.
† Removed December 22, 1872, and Val de Travers compressed asphalt laid in its place.
‡ Removed September 12, 1873, and Val de Travers compressed asphalt laid in its place.
§ Removed February 21, 1874, and Val de Travers compressed asphalt laid in its place.

The statements as to the composition of some of the factitious asphalts are as given by the patentees or proprietors.

WM. HAYWOOD.

MARCH 17, 1874.

COST OF MAINTAINING LONDON PAVEMENTS.

ENGINEER AND SURVEYOR'S DEPARTMENT,
Sewers Office, Guildhall, January 24, 1882.

To the honorable the COMMISSIONERS OF SEWERS OF THE CITY OF LONDON:

GENTLEMEN: In pursuance of your reference I beg to lay before you a table giving the annual cost of maintaining in good condition certain of the principal asphalt, wood, and granite carriage-way pavements in the city of London.

The following information is given to enable their relative costs to be properly considered:

ASPHALT PAVEMENTS.

Asphalt pavements are as a rule maintained by the contractors, subject to the following conditions:

The contracts are for a term of 17 years.

For the first 2 years the pavements are maintained at the cost of the contractors, and for the remaining 15 at the cost of the commission at contract prices per square yard per annum, measured over the whole surface of the pavements, for which the contractors are bound to keep the pavements in a good state of repair. At the termination of the contracts the pavements are to be left in a good condition to the satisfaction of the engineer, and so that a square yard of the asphalt is not to weigh less than a specified weight.

WOOD PAVEMENTS.

The contracts for maintaining these are also for 17 years, for the first 2 of which they are maintained at the cost of the contractor, and subsequently, as in the case of the asphalt, at the cost of the commission at a tendered price per square yard per annum, measured over the whole surface, the pavements at the expiration of the term to be in good condition and to the satisfaction of the engineer.

There are a few exceptions, however, both in asphalt and wood, to the mode of contracting for maintenance.

GRANITE PAVEMENTS.

The commission has never contracted for maintaining granite pavements upon the same basis as they have those of wood and asphalt, but the necessary work to the granite has been executed when needed, and paid for according to a schedule of prices contracted for. As far as practicable all the work is measured up.

As almost every main thoroughfare in the city has now for years been paved with wood or asphalt, the best thing is to lay before the commission the estimates of the cost of certain main thoroughfares which were made when they were paved with granite, and just before wood and asphalt were introduced.

The mode of maintaining the granite pavements must also be explained.

It was the custom to lay new granite almost exclusively in main thoroughfares, and when a pavement was so worn as to need a general relay, to remove it altogether and lay a new one in its place. The pavements in main thoroughfares were, therefore, nearly always removed long before they were worn out; this was done so that those streets where the traffic was the greatest might have the best pavements, as well as for other reasons.

The old stones were removed to the stone yard, mixed with the general stock, redressed, sorted into sizes, and then laid in secondary or third-class streets.

Thus it most frequently happened that granite paving stones, first laid in a main thoroughfare, passed, when redressed, into a second-class thoroughfare, and ultimately into one of but little traffic; owing to this system, although the cost of the small repairs of a granite pavement made yearly could readily be arrived at, the total cost of the maintenance over long periods could only be estimated.

I have the honor to remain, gentlemen, your most obedient servant,

W. HAYWOOD,
Engineer and Surveyor.

Return showing the annual cost of maintaining the carriage-way pavements in some of the principal thoroughfares of the city of London.

ASPHALT PAVEMENTS.

Name of thoroughfare.	Description of pavement.	Annual cost of maintenance per yard superficial.
		s. d.
Bishopsgate street within	Val de Travers asphalt	1 3
Cheapside and Poultry	....do	1 6
Fenchurch street, between Gracechurch street and Railway place.	....do	1 6
Finsbury pavement and Moorgate	....do	0 9
Gracechurch street	....do	1 0
Gresham street	....do	1 3
King William street, narrow portion	....do	1 3
London wall	....do	0 9
Moorgate street, between Coleman street buildings and London wall.	....do	0 9
Moorgate street, between Lothbury and Telegraph street.	....do	1 0
New Broad street and Old Broad street	....do	0 9
Paternoster row	....do	1 0
Queen street, between Cheapside and Pancras lane	....do	0 9
Queen street, between Pancras lane and Queen Victoria street.	....do	1 3
Threadneedle street	....do	1 3
Queen Victoria street, from Mansion House to Cannon street.	....do	0 6
Aldgate	Limmer asphalt	0 9
Cornhill	....do	0 9
Lombard street	....do	0 9
Mark lane	....do	1 0
Mincing lane	....do	0 0
Moorgate street, from Telegraph street to Coleman street buildings.	....do	0 9
Newgate street	....do	0 9

Return showing the annual cost of maintaining the carriage-way pavements, etc.—Cont'd.

ASPHALT PAVEMENTS—Continued.

Name of thoroughfare.	Description of pavements.	Annual cost of maintenance per yard superficial.
		s. d.
Fenchurch street (eastern end)	Société Francaise des asphaltes.	0 9
King street, Cheapside	....do	0 9
Princes street (part of)	....do	1 3
Philpot lane	....do	0 6
Milton street	....do	0 6

WOOD PAVEMENTS.

Aldgate High street	Improved wood	1 0
Bishopsgate street without	....do	1 0
Barbican	....do	1 0
Holborn	....do	1 0
Jewin street	....do	0 10
King William street and Adelaide place	....do	1 6
New Bridge street	....do	1 0
St. Paul's churchyard (western end)	....do	1 3
St. Mary Axe	....do	0 9
Walbrook	Mowlem's wood	1 9
Wormwood street	....do	1 0
Fleet street (west end)	Henson's wood	1 0
Leadenhall street (east end)	....do	1 6
Minories	....do	1 6
Fleet street (eastern half)	Asphaltic wood	1 0
Queen street, between Cannon street and Upper Thames street.	....do	0 10
Cannon street	Carey's wood	1
St. Paul's churchyard (south and east sides)	Gabriel's wood	[illegible]

GRANITE PAVEMENTS.

Cheapside	Aberdeen granite 3 by 9 inches	0 6¾
Poultry	....do	0 9½
Old Broad street	....do	0 3
Moorgate street	....do	0 3¾
Lombard street	....do	0 3¼

These are the sums actually paid for jobbing, repairs, and maintaining the pavements generally in a good condition until a relay of the entire surface was needed, when, as stated in the report, page 6, the pavements were replaced by new.

In 1871 I estimated the total cost per square yard of granite pavements in these thoroughfares, assuming that the granite had remained in them until thoroughly worn out, and distributing the first cost of the pavements over their duration, was as follows:

Situation.	Average cost per square yard per annum, including first cost and maintenance.
	s. d.
Cheapside	1 7½
Poultry	2 9½
Old Broad street	1 0½
Moorgate street	1 4½
Lombard street	1 0¾

W. HAYWOOD,
Engineer and Surveyor.

LIVERPOOL DISTRICT.

REPORT BY CONSUL SHERMAN.

STREETS.

For particulars of the best class of city street pavement I refer to the report published in Consular Reports No. 117. [Inserted herein].

A more common method where the traffic is heavy is as follows: On a bed of ashes or broken stone, rolled and consolidated, is placed a layer of 1 inch to 1½ inches of sand, and on this Welsh granite sets from 8 to 12 inches long by 6 inches deep and 3 inches wide are laid and the joints run with asphalt. Where the traffic is lighter grit-stone sets 8 to 12 inches long, 8 inches deep, and 6 inches wide are used. These are laid as above, but the joints are simply filled with sand or gravel.

STREETS AND SEWERS OF LIVERPOOL.*

STREET PAVEMENTS.

After many years of experiment and the expenditure of vast sums of money in pavements the corporation of Liverpool now points with justifiable pride to its 250 miles of the best paved streets in the world.

The policy adopted by this corporation in the execution of public works in the best possible manner, and generally by their own workmen, has proved successful in every way; and, by a judicious capital expenditure, the cost of maintenance of the roads, sewers, and other public works is reduced to a minimum, and the greatest economy is thereby attained.

The laying of the impervious pavement which was adopted in 1872 for the carriage-ways of the city has been continued up to date without intermission, and is still in progress, resulting in nearly 1,750,000 yards superficial of impervious carriage-way pavements and a saving by the execution of this class of work unprecedented in municipal experience.

The financial result can best be shown by the following: Dealing with the year 1879, under the present city engineer (Mr. Clement Dunscombe, M. A., M. Inst. C. E.), the estimated expenditure for the general repairs to the roads in this city was £28,000 ($136,080), the mileage of adopted roads at that time being 226 miles. Concurrently with the extension of the impervious carriage-way pavements, the expenditure under this head has been reduced year by year till the estimated cost for the current year (1889) is only £8,400 ($40,824), with a street mileage under repair of 254 miles. This reduction has not been effected, as might at first sight be supposed, by an increased rate under this head, due to an augmented capital expenditure requiring the provision of additional interest and sinking fund to redeem the original debt for paving and like works within 23 years (from 1870, when the loan was effected, to 1893, when it will be paid), as the amount raised on paving rate account in the year 1879 was, approximately, £17,000 ($82,620) more than in the year 1889, although the interest and sinking fund on the debt had increased from about £13,000 ($63,180) per annum in the year 1879 to about £47,000 ($228,420) per annum in the year 1889.

Appended hereto are the specifications for paving first, second, and third class streets.

Pavement designated as first class is usually laid down in the main streets of heavy traffic in the central parts of the city.

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* From Consular Reports, No. 117, for June, 1890.

Permission is never given to private companies or persons to cut through the pavement in any street for any purpose. When such work is necessary, the corporation will do it in its own thorough way, and the interested parties must pay the entire cost—a regulation worth noting.

PAVING SPECIFICATIONS.

First-class streets.—Excavate or fill in the ground, as the case may be, to the requisite level, and remove all surplus material. Properly form and trim off the surface and thoroughly consolidate the same, and then lay a foundation of not less than 6 inches of Portland cement concrete, corporation standard. The paving shall consist of granite or syenite sets, 3½ inches wide by 6½ inches deep, from North Wales or other approved quarries, laid in regular, straight, and properly bonded courses, with close joints, and to be evenly bedded on a layer of fine gravel half an inch in thickness. After the paving is laid the joints shall be filled with hard, clean, dry shingle; the sets shall then be thoroughly rammed and additional shingle added until the joints are perfectly full. The joints shall then be carefully grouted until completely filled with hot asphalt, composed of coal pitch and creosote oil, and finally the paving is to be covered with half an inch of sharp gravel.

The crossings shall consist of three rows of 16 by 8 inch granite crossing stones, and the remaining space shall be paved on each side of the crossing stones to the full width of the footway, in a similar manner to the carriage way. The crossing stones shall be of granite of a quality to be approved by the engineer, dressed perfectly true, and out of winding on the face; the sides and joints to be perfectly square and accurately dressed throughout their entire depth; the stones to be bedded on cement concrete, the joints to be filled with shingle and grouted with hot asphalt. A triangular groove an inch wide by three-fourths of an inch deep to be run along the upper surface of each stone. No stone to be less than 3 feet in length.

The footways shall be paved with Yorkshire or Lancashire flags of the best quality, not less than 3 inches thick. No flag to measure less than 2 feet in width or to be of less area than 6 feet; to be solid, free from laminations, the upper surface to be true and free from windings or hollows; the joints to be squared the whole thickness. The flags to be laid on a bed of fine gravel, with close, neat joints flushed in mortar, and in uniform courses breaking bond. The joints to be dressed after laying, where necessary.

The channel stones to be of granite or syenite, of a quality to be approved by the engineer, and to be not less than 3 feet in length. The upper surface, if not self-faced and perfectly true, must be accurately worked out of winding, the bed even and parallel to the face, the sides and ends truly square; the stones to be bedded on cement concrete, and the joints to be filled with clean shingle and grouted with hot asphalt.

The curbstones to be granite or syenite, straight or circular as required, 6 inches thick at top, 7 inches thick at 5 inches below, and not less than that thickness for the remainder of the depth; to be not less than 12 inches deep nor less than 3 feet in length; to be carefully dressed on top, 8 inches down the face, and 3 inches down the back; the remainder of each stone to be hammer dressed; the heading joints to be neatly and accurately squared throughout the entire depth.

Second-class streets.—Excavate or fill in the ground, as the case may be, to the requisite level, and remove all surplus material; properly form and trim off the surface; and thoroughly consolidate the same, and then lay a foundation of (*a*) not less than 6 inches of Portland cement concrete, corporation standard, or (*b*) not less than 6 inches of bituminous concrete, consisting of clean and angular broken stone, grouted with hot asphalt composed of coal pitch and creosote oil, covered with chippings, and thoroughly consolidated by rolling with a roller of sufficient weight. The paving shall consist of granite or syenite sets 3 inches wide by 5 inches deep, or of granite or syenite 4 by 4 inch cubes from North Wales or other approved quarries, laid in

regular, straight, and properly bonded courses, with close joints, and to be evenly bedded on a layer of fine gravel half an inch in thickness. After the paving is laid the joints shall be filled with clean, hard, dry shingle; the sets shall then be thoroughly rammed, and additional shingle added until the joints are perfectly full. The joints shall then be carefully grouted until completely filled with hot asphalt composed of coal pitch and creosote oil, and, finally, the paving shall be covered with half an inch of sharp gravel.

The crossings, footways, channels, and curbs shall be the same as specified for first-class streets.

Third-class streets.—Excavate or fill in the ground, as the case may be, to the requisite level, and remove all surplus material; properly form and trim off the surface and thoroughly consolidate the same, and then lay a foundation of hand-pitched rock 6 inches in depth, set on edge in the manner of a rough pavement. Over this a coating of gravel is to be laid of sufficient thickness to fill in the interstices and to form a smooth surface to the foundation, which must be thoroughly consolidated by rolling with a steam roller before the paving is laid. The paving shall consist of 4 by 4 inch granite or syenite cubes from North Wales or other approved quarries, laid in regular, straight, and properly bonded courses, with close joints, and to be evenly bedded on a layer of fine gravel half an inch in thickness. After the paving is laid the joints shall be filled with clean, hard, dry shingle; the sets shall then be thoroughly rammed and additional shingle added until the joints are perfectly full. The joints shall then be carefully grouted, until completely filled up, with hot asphalt composed of coal pitch and creosote oil, and, finally, the paving shall be covered with half an inch of sharp gravel.

The crossings, footways, channels, and curbs shall be the same as specified for first-class streets.

STREET RAILWAYS.

All the street railway tracks (tramways) are laid and owned and kept in condition by the corporation, and the company leasing them for traffic pays an annual rental of 10 per cent. on their cost.

The superb manner in which these rails are placed is fully shown in an illustrated report of the city engineer, from which I quote:

"The Liverpool city lines as now laid * * * are conclusive proof that when tramways are well designed and properly constructed they do not form the slightest impediment even to the narrowest wheeled vehicles."

SEWERS.

During the past 17 years the corporation has expended for sewerage works approximately £350,000 ($1,703,000), and this outlay has been thoroughly reproductive from a sanitary point of view in a lessened mortality rate. Interesting details on this subject are given in the illustrated report of the city engineer which is inclosed herewith.

SEWERS OF LIVERPOOL.

[Extracts from the annual report of the city engineer, Mr. Dunscombe.]

Ventilation of sewers.

Prior to 1871 there were no ventilators fixed upon the main sewers in the city. At that date 1,046 Archimedean screw ventilators, 6 inches in diameter, were connected with the branch sewers from courts, the 6-inch pipe being attached to the side of one of the court houses wherever permission could be obtained. Of this number there are at the present time 976 remaining, which includes a few shaft ventilators added since 1871, mainly in confined situations where open grid ventilation was found to be

objectionable, the demolition of insanitary court houses and of property for railway and other improvements having reduced the number that were originally fixed.*

The cost of these ventilators, including fixing, is stated to be £10 each, and the annual cost of maintenance about 5*s.* each.

Ventilating grids or ventilating manhole covers, as the case may be, the clear opening in each being not less than 63 square inches, have been fixed along the main sewers at a distance apart of 80 yards approximately.

Drawing No. 1, figure 1, shows the arrangement adopted where the ventilating grating is fixed over a chamber constructed at the side of a manhole.

Drawing No. 1, figure 2, shows a manhole cover and ventilator combined.

Where the distance between the manholes is more than the specified distance apart of 80 yards, ventilating grids, as shown in drawing No. 1, Fig. 4, have been fixed on special shafts over the sewer, so that this uniform distance is maintained throughout.

Prior to 1876 detail records do not seem to have been kept in the engineer's department of the rate of progress of this work, but it appears that up to that year 28 miles of main sewers had been ventilated.

With the exception of those sewers into which hot water is discharged or steam injected, and which are few in number, the ventilation of the whole of the Liverpool main sewers was completed in 1882, embracing the following mileage, viz:

	Miles
Up to 1876	28
1876	16
1877	18
1878	12
1879	41
1880	35
1881	25
1882	2
Length of sewers ventilated to year 1882	177
New sewers constructed and old sewers reconstructed from 1876 to 1885 inclusive	72
Total mileage of brick and pipe sewers ventilated to year 1885	249

All new sewers are now ventilated in a similar manner, as their construction proceeds.

The total cost of ventilation has been £12,000, or 7*d.* per yard run of sewer.

Reconstruction and alteration of gullies.

The records of the progress of this work up to 1880 appear to be incomplete. Since that year all defective gullies have been altered, improved, or reconstructed practically in accordance with drawing No. 1, Fig. 3, and all new gullies have been built in accordance with this drawing.

This form of gully combines the essentials requisite to reduce to a minimum the quantity of detritus entering the sewers.

Up to date 5,219 gullies have been constructed or reconstructed.

Cleansing of sewers.

No systematic cleansing of the sewers appears to have obtained prior to 1871, but from that year systematic cleansing of the main sewers in the lower districts of the city and tide-locked sewers has been carried out, in addition to the cleansing which takes place previous to the execution of repairs.

* As regards the Archimedean screw ventilators, Drs. Parkes and Sanderson state in their report as their opinion that, notwithstanding the mechanical efficiency of the Archimedean screw ventilators, they exercise no practical influence in preventing the escape of sewer air into the streets and houses.

The necessity for cleansing the sewers which have been repaired and the gullies emptying into same rebuilt has been in a great measure obviated owing to—

(1) The improved construction of the gullies, by which less detritus enters the sewers, the extension of impervious pavements of slow-wearing material, and the reduction in the area of macadamized roads.

(2) The generally self-cleansing condition of the sewers as repaired, and their systematic flushing.

The cost of this work for the parish is £1,302 per annum, and for the out townships £1,736 per annum.

Repairs on rates account.

Preparatory to executing any repairs in a sewer it is thoroughly cleansed, and then inspected to ascertain what repairs are necessary, in order to put it into perfect condition and make it, in the future, as far as possible self-cleansing.

The repairs executed to the sewers are: (1) Repairs dependent upon the defective junction of branch sewers with main sewers, either in plan or section; (2) repairs required consequent upon the natural decay or wearing away of the materials forming the sewer.

(1) *Defective junction of branch sewers with main sewers.*—Where a branch sewer meets a main brick sewer at the same invert level, this has been altered, wherever the gradient would admit of it, by raising the invert level so that it outlets into the main at its proper relative level and running the gradient out to meet the ordinary gradient of the branch sewer—the work being executed in Portland cement concrete. Where a branch meets the main sewer at right angles, the junction is altered to a curve of moderate radius.

(2) *Sewers decayed and worn.*—In the case of repairs consequent upon the natural decay of wearing away of the materials forming the sewer, the mode of procedure is as follows:

(*a*) *Pointing.*—After cleansing and examination the class of repairs required is decided upon. In some cases the raking out of the joints of the brickwork, washing it, and repointing in Portland cement mortar mixed in the proportions of 1 of cement to 1 of sand will meet the case.

(*b*) *Pointing and reinverting.*—In some instances the invert of the sewer is found to be worn away, or constructed so unevenly as to assist the formation of deposit. In this case, in addition to the pointing already described, the invert of the sewer is improved in cross-section and gradient, the mode of procedure being as follows:

The sewer being cleansed, the joints are raked out, as before stated, and the sewer is reinverted with Portland cement concrete averaging 2 parts of river gravel to 1 part of cement, the surface being finished in the proportion of 1 part of cement to 1 part of gravel.

This mode of treatment constitutes the work executed in the majority of the old sewers dealt with in the parish of Liverpool.

Owing to the large dimensions of the main sewers, the whole of the operations in connection with their repair are conducted without in any way disturbing the pavements; the work is executed between manhole and manhole, the sewage in the sewer operated upon being dammed back at the point under repair and provision made for the discharge of the sewage through pipes or open troughs suspended from the portion of sewer undergoing repairs. After the lapse of about 4 days from completion of the respective repairs the sewage is again allowed to flow through the sewer.

Reconstruction on capital account.

(1) *Defective construction or workmanship.*—(*a*) These consist generally of sewers driven in headings prepared for 9-inch work. The sewers have only been executed in 4½-inch work, except at the termination of each center length, the space between

the brick arch and the rock roof, including the space for the 4½-inch ring of brickwork omitted, not being filled in with any material.

(*b*) Sewers for which the headings have been taken out considerably larger than actually required for the size of the sewer and thickness of brickwork, and this extra space in the heading above the 9-inch brickwork has not been filled in.

These sewers are practically the same as shown in drawing No. 4, Figs. 1 and 2, with the exception that the thickness of the brickwork of the arch is 9 inches throughout.

In heavy storms they will probably run full and under considerable pressure, and when these defects exist the crown of the sewer is lifted and the arch fractured. Their reconstruction consists in re-arching and filling in the headings solid. The inverts of many of these sewers are, in addition, found to have worn away considerably, and advantage is taken, when executing the work of re-arching, to reline the invert with radiating blue bricks.

Examples of defects *a* and *b* have occurred as follows, viz: Bankhall relieving sewer, from Stanley road to the canal, is a type of the class *a;* in 1883 the arch of this sewer was reconstructed and the invert lined with blue bricks. Sandhills lane outfall sewer, which is 6 feet by 4 feet, is an example of *b* as described; the portion passing under Great Homer street and Smith street has already been completed, and the length passing under Lambeth road and Sandhills lane has been recently commenced.

(2) *Sewers driven in the sandstone rock.*—The next description of sewers which require reconstruction are those which are found on examination to be simply headings driven through the sandstone rock neither in line nor level. New brick sewers were constructed within these headings in proper direction and level, the remaining portion of the heading being carefully filled in. Types of sewers which have been recently dealt with were situated in Catharine street, Canning street, Percy street, Huskisson street, etc.

(3) *Brick sewers past repair.*—Sewers past repair, owing to natural decay of the materials of which they are formed, and therefore require to be constructed anew. When these sewers are reconstructed advantage is taken, wherever possible, to improve their level, gradient, and cross-section. Types of sewers recently dealt with were Waterloo road, Bath street, Grundy street, Errington street, Haigh street, and Dingle outfall sewers.

(4) *Pipe-passage sewers.*—These sewers, when found to be defective, are reconstructed. Generally, those dealt with have been laid for many years, and the defects in them consist principally in the quality of the pipes and mode of jointing. In many cases, owing to the ground being filled-in ground, its subsequent settlement has caused inequalities in the line of sewer and breakages of the pipes, resulting in stoppages and rendering anything short of reconstruction unsatisfactory. Such sewers have generally been found in the older residential parts of the city.

Since 1879, 14 miles of main sewers, mostly of large capacity, have been reconstructed at a cost of £51,739.

New brick sewers.

All new brick sewers are generally constructed in accordance with drawing No. 4, Fig. 4, with bricks molded to the respective radii, and in certain cases the invert is lined with best radiating blue bricks.

Progress of repairs.

The following table shows the areas dealt with from 1873 to 1885, inclusive:

Years.	Acres.	Miles of sewers repaired.
1873–'75	206	13
1876–'79	781	28
1880–'85	657	37½

The results from these repairs have been most satisfactory, both on sanitary and economical grounds.

(1) Freedom from deposits in the sewers and a quicker discharge of the sewage to the respective outfalls, and consequent lessened impurity of the sewer air, which can thus be more readily rendered perfectly innocuous by dilution with fresh air through the open gratings fixed over the sewers. When the main causes of the impurity of the sewer air, viz, deposits in the sewers, are removed, open grid ventilation, as adopted in Liverpool, by which means the sewer air is diluted, is an effective system which can be carried out at a moderate cost.

(2) On economical grounds the repairs have been satisfactory, by diminished cleansing of the sewers repaired, and preventing the necessity of reconstructing the sewers so dealt with at some future time at considerable cost.

When large volumes of hot water discharge into a sewer and can not be prevented, and where wastes from chemical or other works empty into it, special means of ventilation other than by open grids is necessary, and in certain cases it may be preferable to construct a special drain for these discharges.

Permanency of repairs.

In order to ascertain the permanency of repairs executed as already described, the engineer has caused a careful examination to be made of eighty of the sewers, selected at random, which were repaired between 1873 and the present time.

The selected sewers in which repairs have been executed during the years 1873'–75, and which may be taken as representative ones for those years, have evidently had little done to them, the principal work being cementing the invert and rough pointing. Some of these sewers may probably require to be again repaired within a period of from 10 to 15 years. The amount expended in these sewers has evidently been small, and consequently the repairs in them can not be expected to last so long as those done at subsequent periods. The expenditure, however, has been more than recouped by the saving effected in cleansing them and their increased efficiency. From 1876 to 1878 the repairs executed have been of a far more substantial character, and may reasonably be expected to last many years. From 1879 to date, the repairs have been executed strictly in accordance with the methods previously described, and the quality of the work can not well be improved; the sewers as now repaired are practically equal to new ones.

The superiority of the work in recent years is readily accounted for—all the men now engaged upon the work are well trained in the various classes of repairs requisite. Skilled bricklayers are employed to execute the work, which, in addition, is carefully supervised. Portland cement concrete or mortar only is used.

House-drainage regulations.

In 1882 the engineer prepared draft by-laws with respect to the drainage of buildings. They were duly approved by the health committee, and were subsequently confirmed by the local government board in November, 1883. From this date all new buildings erected in the city have been drained in conformity with these regulations, which are found to work satisfactorily.

Except in the center of the parish of Liverpool, the houses are drained on what may be termed the "back drainage" system, the drains discharging into the passing sewer at the rear of the premises, avoiding the necessity of any of them passing under the buildings, and admitting of the houses being drained on the best sanitary principles, and affording easy means for their periodical inspection.

The estimated cost of executing the drainage of a cottage house in Liverpool under these regulations, inclusive of closet-pan and siphon, siphon-trap and waste from sink, also bath waste, is, in the case of a cottage house with an external water-closet, £3 10*s.*, and, with an internal water-closet in addition, £4 5*s.*

With such additional appliances and fittings as may be requisite the system of drainage adopted for the cottage house is equally applicable in degree to the largest houses in the city. The highest sanitary standard of house drainage is extremely simple in arrangement and need not necessarily be expensive, but, on the other hand, can in ordinary cases be carried out at such a moderate expenditure as should encourage owners of house property to reconstruct the drainage of same where it is not in accordance with the most modern practice as defined by these drainage regulations.

Flushing of sewers and private drains.

All main sewers that are not self-cleansing are periodically flushed by large movable tanks placed over a manhole on the sewer. These tanks contain 1,800 gallons of water, and discharge their contents into the sewer through a valve at the bottom of the tank in 28 seconds. The cost of this work is about £1,200 per annum. All passage sewers are flushed four times annually by special gangs, either from chambers at the head of each sewer or by hose connected with hydrants fixed in convenient positions, and, in addition, they are indirectly flushed twice annually by the private drains flushing gang. The cost of this work is about £1,100 per annum.

In December, 1880, on the recommendation of the engineer, the health committee resolved to flush all private drains twice annually, free of cost to the occupiers, and oftener on payment of a small fee, regulated according to the ratable value of the premises, and this work has since been regularly carried out. It is so arranged that a flushing gang visits each house in the city once every six months.

The staff for this work comprises one flushing inspector, one foreman, and sixteen gangs of three men each.

The drains, water-closets, and soil-pipes within the curtilage of all premises are flushed by hose attached to hydrants fixed at convenient distances in the passages or adjacent streets.

The occupiers of the houses willingly coöperate and afford every facility for executing this important sanitary work, and although 107,000 houses, exclusive of warehouses, stores, offices, etc., are visited twice annually, few complaints reach the department relative to the manner in which any of the operations are conducted.

The cost of this work is £5,000 per annum, or under 6*d.* per house for each flushing. In all cases the water is supplied free of cost by the water committee of the corporation.

Inspection of main sewers by special gangs.

This work has only been carried out systematically since October, 1885. Previous to that date, however, all sewers were examined wherever connections were made with them for the drainage of property, also prior to cleansing or executing repairs or other work, and reports made as to their condition either by the sewer inspectors or workmen engaged, so that practically the inspectors and workmen were conversant generally with the condition of the sewers. The periodical inspection of all the sewers is, however, preferable.

So far as the inspection has gone, which in the future will be a continuous one, it has been ascertained that the remaining sewers in Liverpool will in every case require to be dealt with as already described.

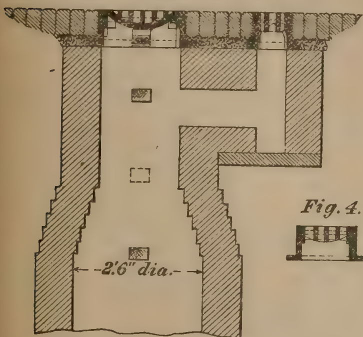
Expenditure.

From the table annexed it will be seen that the majority of the repairs up to the present date have been carried out within the parish. The engineer estimates that the corporation has expended, from 1873 to date, the following sums in repairs and cleansing consequent on repairs :

Years.	Parish of Liverpool.	Township of Kirk-dale.	Township of Everton.	Township of West Derby.	Township of Toxteth Park.
1873–'79	£19, 520	....	£600	£200	£1, 270
1880–'85	59, 486	£1, 955	3, 795	4, 269	3, 650
Total	79, 006	1, 955	4, 395	4, 469	4, 920

During this period 78½ miles of main sewers have been repaired at a total cost of £94,745. Of this mileage 62¾ miles are in the parish.

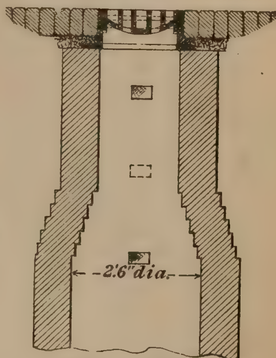
Fig. 1.



SECTION OF MANHOLE SHOWING SOLID COVER AND VENTILATING CHAMBER.

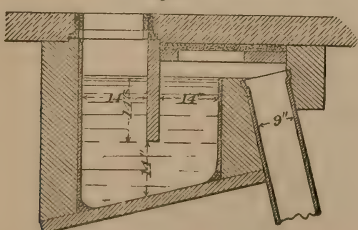
Fig. 4.

Fig. 2.



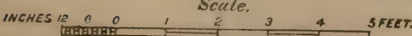
SECTION OF MANHOLE WITH VENTILATING COVER.

Fig. 3.

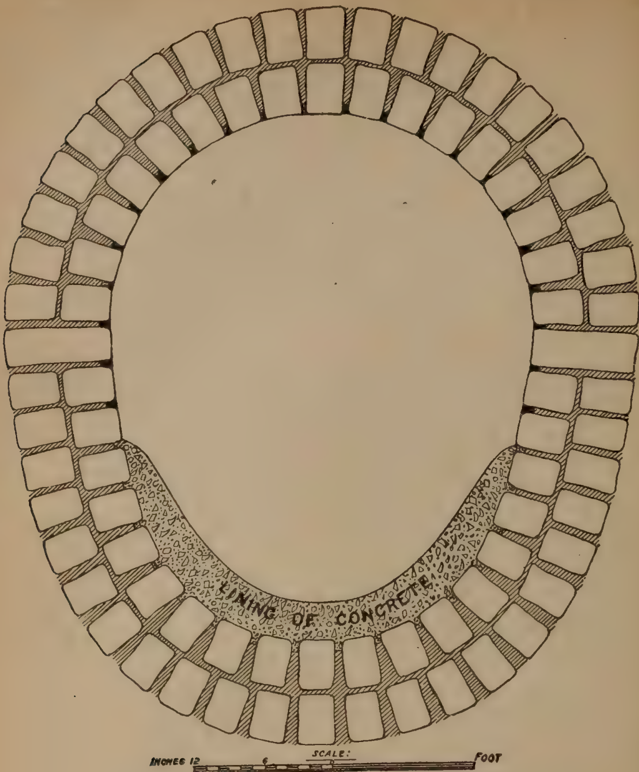


SECTION OF WATER-TRAPPED GULLY.

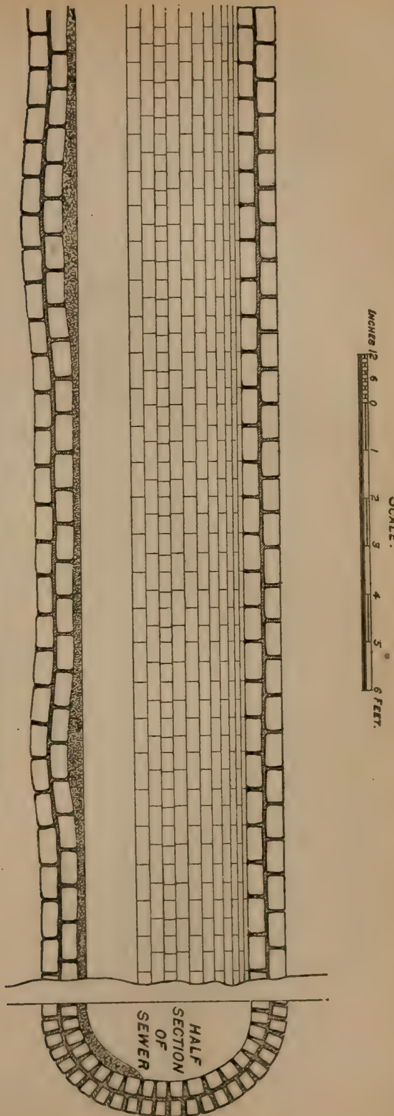
Scale.



DRAWING NO. 1.



DRAWING NO. 2.—Cross-section showing Portland cement concrete invert.



DRAWING No. 3.—Longitudinal section showing Portland cement concrete invert.

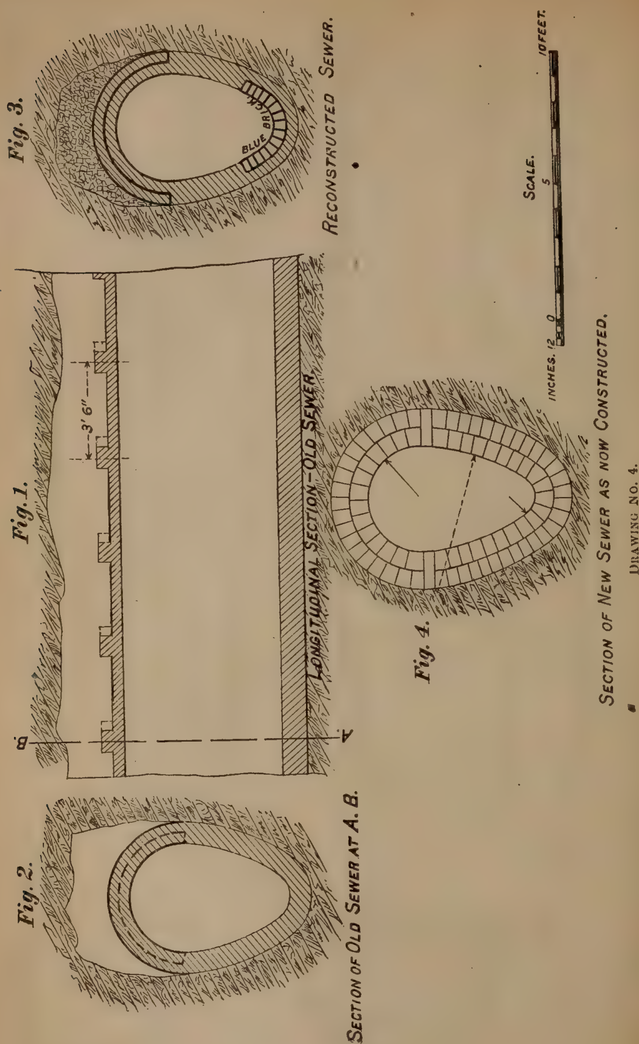
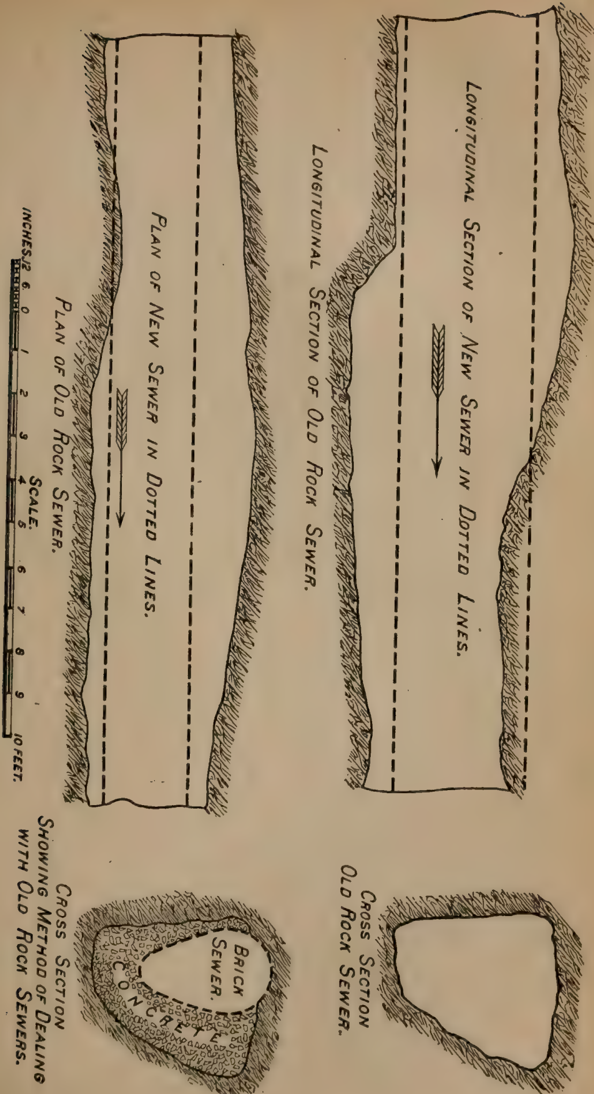


Fig. 3.
BLUE BRICKS
RECONSTRUCTED SEWER.
Fig. 1.
3' 6"
B
A
LONGITUDINAL SECTION—OLD SEWER.
Fig. 2.
SECTION OF OLD SEWER AT A. B.
SCALE.
INCHES. 12 0 5 10 FEET.
Fig. 4.
SECTION OF NEW SEWER AS NOW CONSTRUCTED.

DRAWING NO. 4.



Drawing No. 5.—Plan showing method of dealing with old rock headings which have been used as sewers.

HIGHWAYS.

I am informed that some of the country roads in this vicinity have only the natural foundation, which means no foundation at all, are poorly drained, and have been much neglected, but are now being more carefully treated. Such roads, however, are rarely seen, and in the main the roads are thoroughly made and maintained in good condition. There is but little of the common "dirt road," and this is made here as everywhere else of the material nearest at hand, the expense being entirely for labor. In the vicinity of works and mines where the traffic is heavy more care is taken, and granite is brought by rail for repairing. Where the traffic is lighter the local stone, whatever it may be, is used. In some localities slag and other refuse from works and mines are largely used for country roads and for streets in towns. Such cheap roads being the exception, it is difficult here, where macadam is almost universally adopted, to draw the line between city streets and country roads. Hence what follows in many cases necessarily relates to both.

In a residential district in Cheshire where the traffic is comparatively light all the roads except along the route of the tramway are macadamized. The macadam is 6 inches thick upon a foundation of pitching or rough blocks of sandstone 8 inches thick. The macadam is rolled with a steam roller 10 tons in weight until thoroughly consolidated, a very small quantity of selected road detritus being used with plenty of water during the final operations on the roller.

The surface of the road then receives a liberal sprinkling of granite chippings and the roller again passes over it several times. The macadam is of granite from Penmaenmawr, or from Port Nant, in North Wales, about 100 miles distant, and the rock pitching is obtained from local quarries. A channel at each side of the carriageway is formed of grit channel stones 10 inches wide by 5 inches deep, laid upon a foundation similar to that for the macadam, except in main thoroughfares, where 6 inches of concrete is used instead. The channels are in all cases backed up by the curb, which is laid at an average height of 4 inches above the channel. The cost of the macadam delivered on to the works averages about 9*s.* ($2.19) per ton, and the pitching about 3*s.* ($0.73) per ton, and the channel stones about 2*s.* (48 cents) per yard. The cost of constructing such a road with only the ordinary amount of excavation is about 5*s.* ($1 21) per square yard, and the average cost of maintaining it in this district is at the rate of about 6*d.* (12 cents) per square yard per annum (including scavenging and watering).

The local board of Great Crosby, near Liverpool, generally specifies for 10 inches of hard rock to be properly set on edge, the stones not to exceed 4 inches in breadth, and the interstices closely packed by hand. The average cost of laying the foundation is 40 cents per square yard. The macadam, cubically hand broken to pass through a 2-inch ring, costs $2.30 per ton delivered, and is laid on in two coats properly watered

and rolled with a steam roller, and finished off to a smooth surface by adding fine chippings. This class of roadway costs about 65 cents per square yard, exclusive of foundation. For roads of tar macadam the same quantity of macadam is used and mixed with due proportions of pitch and tar, forming one homogeneous mass. This is rolled with the steam roller, and finished off with fine chippings, no water being used. Average cost 90 cents per square yard, exclusive of foundation. The tar macadam is found to be well adapted to a sandy district, owing to the liability of drift sand to disintegrate an ordinary macadamized roadway. It makes a capital roadway, causes a minimum of dust, and is most rapidly scavenged, but it is very slippery in frosty weather.

In Carnarvonshire, Wales, the best roads have a hand-set pavement for a foundation (the ground first of all being well drained), covered with about 6 inches of metaling broken to a 2-inch gauge, costing $1.50 per ton at the quarry and about $2.25 per ton on the road. The cost of constructing such a road is about $1 per square yard.

In the Wavertree district, near Liverpool, macadamized roads are preferred and the first cost is estimated at about $1.50 per superficial yard, exclusive of sewering. (See specification herewith.)

WAVERTREE DISTRICT.

Specification of works required to be performed and materials to be used in the construction of roads situate in the local government district of Wavertree.

In this specification the following words shall have the meanings hereinafter set forth, namely:

"The contractor" shall mean and include the person or persons agreeing to execute the works described in this specification, and shall also mean and include the executors and administrators of such person or persons and the words in singular number shall include the plural.

"The local board" shall mean the local board of health for the local government district of Wavertree.

"The surveyor" shall mean the surveyor for the time being, of the local board, or other person or persons for the time being, appointed by the said local board, to superintend the execution of the said works.

"The works" shall mean the several works, matters, and things, comprised or referred to in and by this specification, or intended so to be, and by the contractor to be executed and performed.

Excavation.—Excavate or fill in the carriage way to a depth of 16 inches below the finished cross-sectional line of street, which will be calculated at the rate of five-eighth inches to every foot of half the width of the carriage way.

Gullies.—The gullies for the surface drainage to be placed as shown on plan, and encased with 4½ inch brickwork built in cement to the height required, and covered with existing cast-iron gratings, and the connections to gully drains to be made good with Portland cement.

Pitching.—The carriage way to be pitched with 9-inch hard rock pitching or other approved material, set on edge with the widest edge downwards, all projecting edges to be broken off and the interstices to be filled in with stones of equal quality to form a smooth surface, which must be thoroughly consolidated.

Macadam.—The whole of the carriage way to be covered with 7 inches of consolidated Penmaenmaur or Port Nant macadam in two coverings, broken so that the largest dimensions of any piece shall not exceed 2 inches. The first coat to be uniformly spread, immediately after the pitching is pronounced to be satisfactory by the surveyor, and to be well rolled with a steam roller. The second coat to be uniformly applied and well rolled with a steam roller without any blinding, so as to fix each stone in its place, after which the whole surface to be very lightly blinded with macadam chippings and well watered and rolled.

Channels.—To be hard, gray, best quality Haslingden stone from the lower beds 15 inches by 7 inches thick and not less than 3 feet in length, and to be firmly and solidly bedded on gravel or cinders laid on rock pitching, the upper surface if not self faced and perfectly true, must be accurately worked out of winding, the bed even and parallel to the face, one side and ends truly jointed and the macadam side pitched off to line and the joints racked with pea gravel and boiling asphalt, all turns to have granite channels 15 inches by 7 inches worked to the required radii.

Passage crossings.—All crossings to have four courses of hard, gray, best quality Haslingden stone 12 inches by 7 inches thick, truly faced, and square jointed through ends and sides, and in not less than 2 feet 6 inch lengths. Pave between the courses with single runs of Clee Hill sets, and make out the full width of crossing with similar paving, and rack the joints with clean pea gravel and Portland cement.

Curbstones.—To be best quality hard, gray, Haslingden stone 12 inches by 6 inches dressed on top splazed face and 3 inches down the back, the remainder to be hammer dressed, the joints to be neatly and accurately squared throughout the entire depth, and no stone to be less than 3 feet in length. All turns to be granite 12 by 6 from approved quarries and to the required radii.

*Foundation of footways.**—The footways to be carefully leveled and formed by excavating or filling in the ground for the site (care being taken to reserve the old wood fence on west side for re-erection) in accordance with the drawings, and a foundation formed of a bed of cinders or gravel 3 inches deep, well pommed.

Flagging.—The footpaths to be laid with 3-inch hard, gray, best quality Haslingden flags, taken out of winding. No flag to be less than 4 feet superficial, and not less than 1 foot 9 inches wide. The joints to be well squared (not pitched off), and jointed with hydraulic lime mortar in the proportions of one of lime to two of clean, sharp sand, and to be well bedded and driven close to joint, and when necessary the flags shall be cut to the steps or other projections and all holes cut for pins, gas columns and water boxes. The flagging when complete shall have a fall towards the channel of ½ inch to the foot.

Lamp columns.—Provide and fix where shown on plan extra lamp columns and heads equal to sample, and allow £15 0s. 0d. for gas company's charges.

ISAAC DIXON,
Surveyor.

JULY, 1890.

In the Garston local district, adjoining Liverpool, macadamized and "bituminous concrete" carriageways are favorites. Official specifications for each are annexed.

* Street crossings. To have three courses of granite 16 inches by 8 inches grooved, truly faced and square jointed through ends and sides, and in not less than 3 feet lengths and paved to full width of adjoining footpath with granite sets racked with pea gravel and boiling asphalt. Street curbstones: To be hard, gray, Haslingden stone 12 inches by 6 by 5 and all turns to be granite 12 by 6 by 5 from approved quarries and to the required radii.

DISTRICT OF GARSTON.

DESCRIPTION OF WORKS (NO. 1).

SEWERS.

Excavation.—The contractor shall carry out all the excavations required, and shall excavate the trenches to such lengths, breadths, and depths as the engineer may direct, and shall form the bottoms of the same as hereinafter specified. In no case shall the trench be less than 12 inches wider than the external diameter of the sewer to be laid therein. The contractor must be careful in opening the trenches not to remove more of the road surface than, in the opinion of the engineer, is necessary for the proper execution of the work, and must not resort to blasting without the permission of the engineer.

Refilling.—The contractor shall, after the sewers have been laid in the manner hereinafter described, fill in the earth in 6-inch layers, and well water and pun the same until thoroughly consolidated.

Reinstatement.—The contractor shall in all cases reinstate and make good the roads, footpaths, and other surfaces affected by his operations.

Surplus earth.—All surplus earth and superfluous rubbish shall be removed and carted away by and at the expense of the contractor, who shall find a place of deposit for the same.

Pipe sewers.—The contractor shall provide and lay in the respective positions shown on plan, and at the respective depths shown on sections, the requisite lengths of pipe sewers of the following sizes:

Fifteen inches diameter at least $1\frac{1}{4}$ inches thick.

Twelve inches diameter at least $1\frac{1}{16}$ inches thick.

Nine inches diameter at least seven-eighths inch thick.

Six inches diameter at least three-fourths inch thick.

Mode of laying sewers.—In all cases where practicable the sewers shall be laid in open trenches, and no heading or tunnel will be permitted except with the written sanction of the engineer, and where such permission is given, the heading or tunnel shall be open from end to end before any portion of the sewer is laid. The pipes shall be laid singly, and joint holes to receive the sockets must in all cases be made in the bottom of the trench, so that the full length of each pipe between joint and joint may have a bearing on the solid ground.

Mode of jointing pipes.—All pipes shall be jointed with tarred yarn, calked into the sockets, and flushed up with well puddled clay.

Junctions.—The contractor shall provide and fix in the positions shown on the plan or where required, properly formed V junction pipes as under, for connecting gullies and private drains with the main sewers.

Number ——, 15 inches diameter.

Number ——, 12 inches diameter.

Number ——, 9 inches diameter.

Number ——, 6 inches diameter.

It is to be particularly noted that in no case will right-angle junctions be allowed, and that no connection will be permitted to be made by cutting into the pipes.

Stoneware disks.—The contractor shall provide and fix stoneware disks, as under:

Number ——, 12 inches diameter.

Number ——, 9 inches diameter.

Number ——, 6 inches diameter.

The disks must be carefully fitted and securely clayed into the branches of the junction pipes.

Galvanized iron indicators.—The contractor shall provide number —— galvanized iron indicators, of form and dimensions shown on drawing for pointing out the posi-

tions of the junctions, and shall fix them as directed by the engineer, either for the walls, fences, or to stakes 3 inches by 2 inches, driven 2 feet into the ground.

Manholes.—The contractor shall build manholes in the situations shown on plan, in 9-inch brickwork set in Portland cement to top of pipe sewer, and best lias lime mortar the remainder, and of the respective forms and dimensions shown on sections and detail drawings.

Manhole covers.—The contractor shall provide and fix on the tops of the manholes, cast-iron covers of form, size, and weight, and similar in every respect to the covers used by the Garston local board.

Foot irons.—The contractor shall provide and fix the requisite number of foot irons of galvanized wrought-iron bar of the form, size, and similar in every respect to those used by the local board. They are to be placed four courses of brickwork apart, vertically, flattened through the thickness of the walls, and the ends turned up 1½ inches.

Gullies.—The contractor shall provide and fix in the position shown on plan, or where required, 9-inch brick gullies, built in Portland cement, of the form and dimensions shown on detail drawing. Each gully shall have the brickwork carried to the top for the reception of iron gratings, and be connected to the sewers by 6-inch diameter glazed stoneware socket pipes, with syphon blocks laid at one inclination throughout.

Gully gratings.—The contractor shall provide and fix on the top of each gully a cast-iron grating of form, size, and weight and in every respect similar to those used by the local board. Each grating must be firmly bedded on the brickwork in best blue lias lime mortar.

ROADS.

Surface excavation.—The contractor shall remove all obstructions and shall excavate the carriageway to a line 18 inches below the sectional line on drawing No. ——.

Filling.—The contractor shall fill in the ground where required to the level prescribed in the preceding clause (No. 48) with approved material.

Foundation of carriageways.—The contractor shall properly form, roll with horse roller, and water the surfaces for the reception of the road material, and shall hand pitch the whole area of the intended carriageway to a depth of 10 inches with hard rock pitching to the satisfaction of the engineer, the interstices to be well racked up with rock broken small and well rolled with the steam roller.

Superstructure of carriageways.—The contractor shall provide and lay two coats of macadam over the whole area of the carriageway of a total thickness of 6 inches. The first layer, 3 inches thick, shall be composed of good, hard rock stone, broken by hand, small enough to pass through a 2½-inch ring in every direction, blinded with one-half inch of gravel sand of quality specified, and rolled with the local board steam roller until, in the opinion of the engineer, it is sufficiently consolidated to receive the second layer. The contractor shall, on receipt of notice in writing from the engineer, spread a second layer 3 inches thick composed of Penmaenmawr stone, broken by hand, small enough to pass through a 1¾-inch ring in every direction; blind the same throughout with 1 inch of gravel sand of quality specified, and roll the whole area with the steam roller, and water and sweep the same until it is, in the opinion of the engineer, thoroughly consolidated.

Rollers.—The local board steam roller may be hired from the works committee at a charge of 30*s.* per day (including fuel and water), and the horse roller at a charge of 5*s.* per day (excluding horses).

Channels.—The channels shall consist of hard-tooled York stone channel blocks 12 by 6 inches, each stone to be at least 2 feet long, laid to the inclinations longitudinal and transverse, shown on drawing No. ——. They shall be bedded on 2 inches of gravel sand on a hard rock foundation 3 inches deep, and well cramped and bedded solid.

Curbing.—The contractor shall provide and fix the requisite lengths of straight, hard York stone-tooled curbing, 5 inches thick and 12 inches deep. The curbing throughout to be in not less than 3 feet lengths, to be well bedded on 2 inches of gravel sand on a hard rock foundation 3 inches deep, and truly laid and close-jointed. The radiated corners to consist of granite curbs, 5 inches thick and 12 inches deep, laid in the same manner as the York curbs.

Street crossings.—The contractor shall provide and lay crossings where shown on drawing, formed of three rows of hard machine-faced squared York stone crossing blocks, 16 by 7 inches, with V grooves 1 inch wide by three-quarters inch deep in center, and nine rows of Clee Hill sets 7 by 6 by 3 inches, the blocks and sets to be laid on beds of good lias lime and rock concrete 6-inches deep, in 2 inches of good gravel sand, and all the joints to be racked with asphalt, coal pitch, and creosote oil, to be used while hot, and limestone clippings.

Footways.—The contractor shall excavate or fill up the ground as may be required to a line 6 inches below the sectional line on drawing No. ——, and shall form the ground with good hard material to the profile shown on cross-sections, and consolidate the same by horse rolling, watering, or otherwise, as may be required. The footways throughout shall be paved with patent Victoria stone on beds of engine ashes 3 inches deep, and good mortar beds close-jointed with good fine mortar of the requisite fluidity, the radiated corners to be worked according to details, all the stones to be well and solidly bedded.

Old materials.—The contractor must value the old materials (if any) at present on the ground, and must state in his tender the amount he will allow for the same.

QUALITY OF MATERIALS.

Stoneware drain pipes.—The whole of the pipes shall be approved salt-glazed stoneware socket pipes of the best manufacture, sound and thoroughly burnt throughout their whole substance, and the internal and external surfaces smooth and well-glazed. They shall be cylindrical in bore, and internally of the full specified diameter, and shall have whole socket-joints forming a component part of the pipe. The thickness shall be uniform throughout the entire body of the pipe.

No square junctions shall be used.

All pipes shall be made to fit without being chipped.

Lime.—The lime shall be blue lias or other approved hydraulic lime, fresh burnt, and until used in mortar, shall be protected from wet, and as much as possible from the atmosphere.

Portland cement.—The cement used in the works of this contract shall be fresh-burnt Portland cement (obtained from the Rugby Portland Cement Company), of such fineness that samples sifted through a No. 50 gauge wire sieve shall not leave a residue of more than 10 per cent., and of such quality and strength that samples of pure cement, when gauged neat in the ordinary brass moulds shall not become firm in less than 3 hours, and shall, after 7 days' immersion in water, be capable of bearing a tensile strain of 400 pounds on the sectional area of 1 square inch.

Sand.—The sand for mortar shall be clean and sharp, free from all foreign matter, and screened if required by the engineer.

The sand for blinding macadam shall be beach-gravel sand, of quality approved by the engineer, a sample of which may be seen at his office.

Lime mortar.—The lime mortar shall be composed of two parts of best building sand, of approved quality, to one part of lime.

Portland cement mortar.—Portland cement mortar shall be composed of two parts of best building sand, of approved quality, to one part of Portland cement.

Brickwork.—The whole of the brickwork shall be built in Old English bond, unless otherwise directed, lineable, plumb, and solid throughout, carried up uniformly with the facework, and closely bedded in mortar, so that in no case shall four courses, when built, exceed in height four like courses set dry, by more than 1¼ inches, and in order

that every joint may be filled, the brickwork must be completely flushed with mortar of the requisite fluidity. No broken bricks will be allowed except for closers.

The whole of the bricks, except where otherwise specified, shall be best common bricks, hard, sound, and well burnt, of approved quality.

HENRY T. WAKELAM,
Assoc. M. Inst., C. E., Engineer and Surveyor.

DESCRIPTION OF WORKS (No. 2).

SEWERS.

Excavation.—The contractor shall carry out all the excavations required, and shall excavate the trenches to such lengths, breadths, and depths as the engineer may direct, and shall form the bottoms of the same as hereinafter specified. In no case shall the trench be less than 12 inches wider than the external diameter of the sewer to be laid therein. The contractor must be careful in opening the trenches not to remove more of the road surface than in the opinion of the engineer is necessary for the proper execution of the work, and must not resort to blasting without the permission of the engineer.

Refilling.—The contractor shall, after the sewers have been laid in the maner hereinafter described, fill in the earth in 6-inch layers, and well water and pound the same until thoroughly consolidated.

Reinstatement of streets, footpaths, etc.—The contractor shall in all cases reinstate and make good the roads, footpaths, and other surfaces affected by his operations.

Surplus earth.—All surplus earth and superfluous rubbish shall be removed and carted away by and at the expense of the contractor, who shall find a place of deposit for the same.

Pipe sewers.—The contractor shall provide and lay in the respective positions shown on plan, and at the respective depths shown on sections, the requisite lengths of pipe sewers, of the following sizes:

Fifteen inches diameter at least 1¼ inches thick.
Twelve inches diameter at least 1$\frac{1}{10}$ inches thick.
Nine inches diameter at least ⅞ inch thick.
Six inches diameter at least ⅝ inch thick.

Mode of laying sewers.—In all cases where practicable the sewers shall be laid in open trenches, and no heading or tunnel will be permitted except with the written sanction of the engineer, and where such permission is given the heading or tunnel shall be open from end to end before any portion of the sewer is laid. The pipes shall be laid singly, and joint holes to receive the sockets must in all cases be made in the bottom of the trench, so that the full length of each pipe between joint and joint may have a bearing on the solid ground.

Mode of jointing pipes.—All pipes shall be jointed with tarred yarn, calked into the sockets, and flushed up with well puddled clay.

Junctions.—The contractor shall provide and fix in the positions shown on the plan or where required, properly formed V junction pipes as under, for connecting gullies and private drains with the main sewers.

Number ——, 15 inches diameter.
Number ——, 12 inches diameter.
Number ——, 9 inches diameter.
Number ——, 6 inches diameter.

It is to be particularly noted that in no case will right angle junctions be allowed, and that no connection will be permitted to be made by cutting into the pipes.

Stoneware disks.—The contractor shall provide and fix stoneware disks, as under—
Number ——, 12 inches diameter.

Number ——, 9 inches diameter.

Number ——, 6 inches diameter.

The disks must be carefully fitted and securely clayed into the branches of the junction pipes.

Galvanized iron indicators.—The contractor shall provide number —— galvanized iron indicators of form and dimensions shown on drawing for pointing out the positions of the junctions, and shall fix them as directed by the engineer either to the walls, fences, or to stakes 3 inches by 2 inches, driven 2 feet into the ground.

Manholes.—The contractor shall build manholes in the situations shown on plan in 9-inch brickwork set in Portland cement to top of pipe sewer, and best lias lime mortar the remainder, and of the respective forms and dimensions shown on sections and detail drawings.

Manhole covers.—The contractor shall provide and fix on the tops of the manholes cast-iron covers of form, size, and weight, and similar in every respect to the covers used by the Garston local board.

Foot irons.—The contractor shall provide and fix the requisite number of foot irons, of galvanized wrought-iron bar, of the form, size, and similar in every respect to those used by the local board. They are to be placed four courses of brick apart vertically, flattened through the thickness of the walls, and the ends turned up 1½ inches.

Gullies.—The contractor shall provide and fix in the position shown on plan, or where required, 9-inch brick gullies, built in Portland cement, of the form and dimensions shown on detail drawing. Each gully shall have the brickwork carried to the top for the reception of iron gratings, and be connected to the sewers by 6-inch diameter glazed stoneware socket pipes, with syphon blocks laid at one inclination throughout.

Gully gratings.—The contractor shall provide and fix on the top of each gully a cast-iron grating, of form, size, and weight and in every respect similar to those used by the local board. Each grating must be firmly bedded on the brickwork in the best blue lias lime mortar.

ROADS.

Surface excavation.—The contractor shall remove all obstructions, and shall excavate the carriageway to a line 18 inches below the sectional line on drawing No. ——.

Filling.—The contractor shall fill in the ground, where required, to the level prescribed in the preceding clause (No. 48) with approved material.

Foundation of carriageways.—The contractor shall properly form, roll with horse roller, and water the surface for the reception of the road material, and shall hand pitch the whole area of the intended carriageway to a depth of 10 inches with hard rock pitching to the satisfaction of the engineer, the interstices to be well racked up with rock broken small, and well rolled with the steam roller.

Superstructure of carriageways.—The contractor shall provide and lay two coats of macadam over the whole of the carriageway to a total thickness of 6 inches. The first layer, 3 inches thick, shall be composed of good hard rock stone, broken by hand small enough to pass through a 2½-inch ring in every direction, blinded with ½ an inch of gravel sand of quality specified, and rolled with the local board steam roller until, in the opinion of the engineer, it is sufficiently consolidated to receive the second layer. The contractor shall, on receipt of notice in writing from the engineer, spread the second layer 3 inches thick, composed of Penmaenmawr stone, broken by hand small enough to pass through a 1¾-inch ring in every direction; the stone to be first well and thoroughly mixed with hot boiled tar and pitch, and then evenly spread and rolled with the steam roller, and then blind the same with an inch of limestone chippings, to pass through a ¾-inch riddle, and not smaller than will pass through a ½-inch riddle, well and thoroughly mixed with hot boiled pitch and tar, evenly spread, and afterward blinded with a coating of fine dry chippings

and rolled with the steam roller until it is, in the opinion of the engineer, thoroughly consolidated.

Rollers.—The local board steam roller may be hired from the works committee at at a charge of 30*s.* per day (excluding fuel and water), and the horse roller at a charge of 5*s.* per day (excluding horses).

Channels.—The channels shall consist of hard-tooled York stone channel blocks 12 by 6 inches, each stone to be at least 2 feet long, laid to the inclinations longitudinal and transverse shown on drawing No. ——. They shall be bedded on 2 inches of gravel sand, on a hard rock foundation 3 inches deep, and well cramped and bedded solid.

Curbing.—The contractor shall provide and fix the requisite lengths of straight hard York stone tooled curbing, 5 inches thick and 12 inches deep. The curbing throughout to be in not less than 3-feet lengths, to be well bedded on 2 inches of gravel sand on a hard rock foundation 3 inches deep, and truly laid and close-jointed. The radiated corners to consist of granite curbs 5 inches thick and 12 inches deep, laid in the same manner as the York curbs.

Street crossings.—The contractor shall provide and lay crossings where shown on drawing, formed of three rows of hard machine-faced squared York stone crossing blocks, 16 inches by 7 inches, with V grooves 1 inch wide by ¾ inch deep in center, and nine rows of Clee Hill sets 7 inches by 6 inches by 3 inches, the blocks and sets to be laid on beds of good lias lime and rock concrete 6 inches deep in 2 inches of good gravel sand, and all the joints to be racked with asphalt, coal pitch, and creosote oil, to be used whilst hot, and limestone chippings.

Footways.—The contractor shall excavate or fill up the ground as may be required to a line 6 inches below the sectional line on drawing No. ——, and shall form the ground with good hard material to the profile shown on cross-sections, and consolidate the same by horse rolling, watering, or otherwise, as may be required. The footways throughout shall be paved with patent Victoria stone on beds of engine ashes 3 inches deep, and good mortar beds close-jointed with good fine mortar of the requisite fluidity, the radiated corners to be worked according to details, all the stones to be well and solidly bedded.

Old materials.—The contractor must value the old materials (if any) at present on the ground, and must state in his tender the amount he will allow for the same.

QUALITY OF MATERIALS.

Stoneware drain pipes.—The whole of the pipes shall be approved salt-glazed stoneware socket pipes of the best manufacture, sound, and thoroughly burnt throughout their whole substance, and the internal and external surfaces smooth and well glazed. They shall be cylindrical in bore, and internally of the full specified diameter, and shall have whole socket joints forming a component part of the pipe. The thickness shall be uniform throughout the entire body of the pipe.

No square junctions shall be used.

All pipes shall be made to fit without being chipped.

Lime.—The lime shall be blue lias or other approved hydraulic lime, fresh burnt, and until used in mortar, shall be protected from wet, and as much as possible from the atmosphere.

Portland cement.—The cement used in the works of this contract shall be fresh-burnt Portland cement (obtained from the Rugby Portland Cement Company), of such fineness that samples sifted through a No. 50 gauge wire sieve, shall not leave a residue of more than 10 per cent., and of such quality and strength that samples of pure cement, when gauged neat in the ordinary brass molds, shall not become firm in less than 3 hours, and shall, after 7 days' immersion in water, be capable of bearing a tensile strain of 400 pounds on the sectional area of 1 square inch.

Sand.—The sand for mortar shall be clean and sharp, free from all foreign matter, and screened, if required, by the engineer.

The sand for blinding macadam, shall be beach-gravel sand, of quality approved by the engineer, a sample of which may be seen at his office.

Lime mortar.—The lime mortar shall be composed of two parts of best building sand of approved quality to one part of lime.

Portland cement mortar.—Portland cement mortar shall be composed of two parts of best building sand of approved quality to one part of Portland cement.

Brickwork.—The whole of the brickwork shall be built in old English bond, unless otherwise directed, lineable, plumb, and solid throughout, carried up uniformly with the facework, and closely bedded in mortar, so that in no case shall four courses, when built, exceed in height four like courses set dry, by more than 1¼ inches, and in order that every joint may be filled, the brickwork must be completely flushed with mortar of the requisite fluidity. No broken bricks will be allowed except for closers.

The whole of the bricks, except where otherwise specified, shall be best common bricks, hard, sound, and well burnt, of approved quality.

HENRY T. WAKELAM,
Assoc. M. Inst. C. E., Engineer and Surveyor.

DESCRIPTION OF WORKS (NO. 3).

SEWERS.

Excavation.—The contractor shall carry out all the excavations required, and shall excavate the trenches to such lengths, breadths, and depths as the engineer may direct, and shall form the bottoms of the same as hereinafter specified. In no case shall the trench be less than 12 inches wider than the external diameter of the sewer to be laid therein. The contractor must be careful in opening the trenches not to remove more of the road surface than in the opinion of the engineer is necessary for the proper execution of the work, and must not resort to blasting without the permission of the engineer.

Refilling.—The contractor shall, after the sewers have been laid in the manner hereinafter described, fill in the earth in 6-inch layers, and well water and pound the same until thoroughly consolidated.

Reinstatement.—The contractor shall in all cases reinstate and make good the roads, footpaths, and other surfaces affected by his operations.

Surplus earth.—All surplus earth and superfluous rubbish shall be removed and carted away by and at the expense of the contractor, who shall find a place of deposit for the same.

Pipe sewers.—The contractor shall provide and lay in the respective positions shown on plan, and at the respective depths shown on sections, the requisite lengths of pipe sewers of the following sizes:

15 inches diameter at least 1¼ inches thick.
12 inches diameter at least 1$\frac{1}{16}$ inches thick.
9 inches diameter at least ⅞ inch thick.
6 inches diameter at least ⅝ inch thick.

Mode of laying sewers.—In all cases where practicable the sewers shall be laid in open trenches, and no heading or tunnel will be permitted except with the written sanction of the engineer, and where such permission is given the heading or tunnel shall be open from end to end before any portion of the sewer is laid. The pipes shall be laid singly, and joint holes to receive the sockets must in all cases be made in the bottom of the trench, so that the full length of each pipe between joint and joint may have a bearing on the solid ground.

Mode of jointing pipes.—All pipes shall be jointed with tarred yarn, caulked into the sockets, and flushed up with well puddled clay.

Junctions.—The contractor shall provide and fix in the positions shown on the plan or where required, properly formed V junction pipes as under, for connecting gullies and private drains with the main sewers.

Number —— 15 inches diameter.
Number —— 12 inches diameter.
Number —— 9 inches diameter.
Number —— 6 inches diameter.

It is to be particularly noted that in no case will right angle junctions be allowed, and that no connection will be permitted to be made by cutting into the pipes.

Stoneware disks.—The contractor shall provide and fix stoneware disks, as under:

Number —— 12 inches diameter.
Number —— 9 inches diameter.
Number —— 6 inches diameter.

The disks must be carefully fitted and securely clayed into the branches of the junction pipes.

Galvanized iron indicators.—The contractor shall provide number —— galvanized iron indicators, of form and dimensions shown on drawing for pointing out the positions of the junctions, and shall fix them as directed by the engineer, either to the walls, fences, or to stakes 3 inches by 2 inches, driven 2 feet into the ground.

Manholes.—The contractor shall build manholes in the situations shown on plan, in 9-inch brickwork, set in Portland cement to top of pipe sewer, and best lias lime mortar the remainder, and of the respective forms and dimensions shown on sections and detail drawings.

Manhole covers.—The contractor shall provide and fix on the tops of the manholes cast-iron covers of form, size, and weight, and similar in every respect to the covers used by the Garston local board.

Foot irons.—The contractor shall provide and fix the requisite number of foot irons, of galvanized wrought-iron bar, of the form, size, and similar in every respect to those used by the local board. They are to be placed four courses of brickwork apart vertically, flattened through the thickness of the walls, and the ends turned up 1½ inches.

Gullies.—The contractor shall provide and fix in the position shown on plan, or where required, 9-inch brick gullies, built in Portland cement, of the form and dimensions shown on detail drawing. Each gully shall have the brickwork carried to the top for the reception of iron gratings, and be connected to the sewers by 6-inch diameter glazed stoneware socket pipes, with siphon blocks laid at one inclination throughout.

Gully gratings.—The contractor shall provide and fix on the top of each gully a cast-iron grating, of form, size, and weight, and in every respect similar to those used by the local board. Each grating must be firmly bedded on the brickwork in best blue lias lime mortar.

ROADS.

Surface excavation.—The contractor shall remove all obstructions, and shall excavate the carriageway to a line 12 inches below the sectional line on drawing No.——

Filling.—The contractor shall fill in the ground where required to the level prescribed in the preceding clause (No. 48) with approved material.

Construction.—The contractor shall provide and lay over the whole of the carriageway good concrete, spread to a depth of 6 inches, laid to the curvature of road; the concrete to be composed of two parts of good hard rock, or other approved stone, broken to pass a 2-inch ring, two parts good clean gravel sand and one part good Portland cement, and shall afterwards provide and lay over the whole surface 4 inches by 4 inches by 4 inches Clee Hill sets (second quality), laid in a bed of gravel sand 2 inches deep; all the joints to be racked with coal pitch, creosote oil, and boiled coal tar asphalt used whilst hot, and limestone chippings; and the whole surface of the carriageway shall afterwards be covered with a layer of asphalt at least one-quarter of an inch in thickness composed as above.

Channels.—The channels shall consist of hard-tooled York stone channel blocks 12 by 6 inches, each stone to be at least 2 feet long, laid to the inclinations longitudinal and transverse, shown on drawings. They shall be bedded on 2 inches of gravel sand on a hard rock foundation 3 inches deep and well cramped and bedded solid.

Curbing.—The contractor shall provide and fix the requisite lengths of straight hard York stone-tooled curbing, 5 inches thick and 12 inches deep. The curbing throughout to be in not less than 3 feet lengths, to be well bedded on 2 inches of gravel sand on a hard-rock foundation 3 inches deep, and truly laid and close jointed. The radiated corners to consist of granite curbs, 5 inches thick and 12 inches deep, laid in the same manner as the York curbs.

Street crossings.—The contractor shall provide and lay crossings where shown on drawing, formed of three rows of hard machine-faced squared York stone crossing blocks, 16 inches by 7 inches, with V grooves 1 inch wide by three-fourths of an inch deep in center, and nine rows of Clee Hill sets 7 inches by 6 inches by 3 inches, the blocks and sets to be laid on beds of good lias lime and rock concrete to 6 inches deep in 2 inches of good gravel sand, and all the joints to be racked with asphalt, coal pitch, and creosote oil, to be used while hot, and limestone chippings.

Footways.—The contractor shall excavate or fill up the ground as may be required to a line 6 inches below the sectional line on drawing No.——, and shall form the ground with good hard material to the profile shown on cross sections, and consolidate the same by horse rolling, watering, or otherwise, as may be required. The footways throughout shall be paved with patent Victoria stone, on beds of engine ashes 3 inches deep, and good mortar beds close jointed with good fine mortar of the requisite fluidity, the radiated corners to be worked according to details, all the stones to be well and solidly bedded.

Old materials.—The contractor must value the old materials (if any) at present on the ground, and must state in his tender the amount he will allow for the same.

QUALITY OF MATERIALS.

Stoneware drain pipes.—The whole of the pipes shall be approved salt-glazed stoneware socket pipes of the best manufacture, sound, and thoroughly burnt throughout their whole substance, and the internal and external surfaces smooth and well glazed. They shall be cylindrical in bore, and internally of the full specified diameter, and shall have whole socket joints forming a component part of the pipe. The thickness shall be uniform throughout the entire body of the pipe.

No square junctions shall be used.

All pipes shall be made to fit without being chipped.

Lime.—The lime shall be blue lias or other approved hydraulic lime, fresh burnt, and until used in mortar, shall be protected from wet, and as much as possible from the atmosphere.

Portland cement.—The cement used in the works of this contract shall be fresh-burnt Portland cement (obtained from the Rugby Portland Cement Co.); of such fineness that samples sifted through a No. 50 gauge wire sieve shall not leave a residue of more than 10 per cent., and of such quality and strength that samples of pure cement, when gauged neat in the ordinary brass molds, shall not become firm in less than 3 hours, and shall, after 7 days' immersion in water, be capable of bearing a tensile strain of 400 pounds on the sectional area of 1 square inch.

Sand.—The sand for mortar shall be clean and sharp, free from all foreign matter, and screened if required by the engineer.

The sand for blinding macadam shall be beach-gravel sand, of quality approved by the engineer, a sample of which may be seen at his office.

Lime mortar.—The lime mortar shall be composed of two parts of best building sand, of approved quality, to one part of lime.

Portland cement mortar.—Portland cement mortar shall be composed of two parts of best building sand, of approved quality, to one part of Portland cement.

Brickwork.—The whole of the brickwork shall be built in old English bond, unless otherwise directed, lineable, plumb, and solid throughout, carried up uniformly with the facework, and closely bedded in mortar, so that in no case shall four courses, when built, exceed in height four like courses set dry, by more than 1¼ inches, and in order that every joint may be filled, the brickwork must be completely flushed with mortar of the requisite fluidity. No broken bricks will be allowed except for closers.

The whole of the bricks, except where otherwise specified, shall be best common bricks, hard, sound, and well burnt, of approved quality.

HENRY T. WAKELAM,
Assoc. M. Inst., C. E., Engineer and Surveyor.

It is evident that in this region macadamized roads are believed to be the best and most economical. I can not therefore do better than annex hereto a paper on "The maintenance of macadamized roads" by W. Hewitt, read at the ordinary general meeting of the Surveyors Institution, November 26, 1888.

I also inclose an official report by Thomas Codrington, C. E., etc., on road maintenance.

Land values undoubtedly are enhanced by good roads, but it is quite impossible to estimate to what extent in this densely populated district.

THOS. H. SHERMAN,
Consul.

UNITED STATES CONSULATE,
Liverpool, March 14, 1891.

MACADAMIZED ROADS.*

BY W. HEWITT.

[Inclosure in Consul Sherman's report.]

Road maintenance is a subject to which comparatively little attention has been given in this country, although it is one of great importance, involving, as it does, inclusive of the metropolitan macadamized roads, an annual expenditure of nearly £4,500,000. In the early part of the last century the roads were little more than cart tracks, on which, when they got in a very bad condition, a quantity of stone of various sizes were placed indiscriminately and left to work in. Of course a road maintained in such a way as this was always in a bad condition, except when the stone was newly put on, and then it was too rough and uneven for the traffic to pass easily over it. In some districts where stone was scarce the road would be mended in the autumn with brushwood, mud, etc., with a layer of stone on the top; but in a short time this road, especially in wet weather, became in a much worse state than before. The method of making a new road was to dig a trench of the required width and deposit a layer of large stones in it and another of small on the top of them. This was left to itself and allowed to consolidate in the best way it could. The thickness of these layers varied according to the idea of the surveyor, and, as he was generally a man possessing no experience of road making or maintaining, it was not to be expected that he would know anything about the work he had to superintend. Things went on in this way until the establishment by law of turnpike trusts.

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* Read at the ordinary general meeting of the Surveyors' Institution, November 26, 1888.

But it appears this did not do much good. The trusts were in short lengths, sometimes not more than 20 miles, and the surveyors were no better than before, as they were more frequently appointed by favor than for any qualifications which they possessed for the office.

This state of things continued until the time of Macadam and Telford (about the commencement of the present century), when great improvements were made; the stone was broken to a more uniform size, and greater attention was paid to drainage. Macadam's principle was "to put broken stone upon a road which shall unite by its own angles so as to form a solid, hard surface," and this by universal experience since has been allowed to be correct. He also contended that no greater convexity should be given to the cross-section of a road than was necessary to carry off the surface water into the water-tables. He did not agree with Telford in one important particular, namely, that a road should have some sort of hard foundation, either a rough hand-set pavement, or a layer of rough stone or gravel for the broken stone to be placed on, preferring to lay the metalling on the formation surface. Experience, however, has since shown that Telford's method was the right one. A great deal has been said about the disagreement between these two eminent men on this particular subject, but it is very evident that they agreed in a great deal more than they differed; and it is by a combination of their methods, united with recent improvements, that the best roads are now made and maintained. In laying out a new road the general lines must always be controlled, more or less, by the surface formation of the locality. Cuttings and embankments should be avoided as much as possible, owing to their great expense, and when unavoidable the work should be so arranged, as far as possible, that the soil removed in cutting can be used for the embankment. It is essential that the formation of a road should be thoroughly drained, whether it has a paved bottom or not. This is usually done by ditches on each side of the road. They should be from 2 feet to 3 feet below the level of the surface of the road. They are sometimes on the land side of the fence, and sometimes on the road side; but it is preferable to have them on the latter, as the roadmen can more easily get at them to clean them out, and it also gives a greater width between the fences, which is a great aid in drying the road, as the air has freer access to it. When the ditches are on the land side of the fence, in most cases they belong to the owners of the property, and the occupiers are supposed to clean and scour them, which there is sometimes great difficulty in getting them to do. When they are on the road side there should be, unless there are footpaths, and when the width will allow, sod borders between the metalled portion of the road and the side ditches, with outlet cuts at short intervals to lead the water away from the surface of the road. In some parts of the country great objection has been made by some members of highway boards to their formation, and they assert that sod borders cause greater expense in the maintenance of the road. This, however, is an error; they may be formed and maintained very inexpensively, and it does not cost nearly so much for trimming the edges and cleaning the outlets as it does to clean the sides of a road by stocking up the weeds and grass. These always accumulate where, as on most country roads, the whole width is not used, and where there is no sod border there is always great expense caused by these operations, which injure the road by admitting the wet, besides being very unsightly; whereas the sod border, when properly kept and trimmed, adds to the appearance of the road and facilitates the flowing away of the surface water. It should be from 4 to 6 inches high, as this would not be high enough to endanger vehicles, and yet high enough to keep anyone from driving into the ditches in the dark.

Where there are many houses on the sides of the road it becomes necessary to have a footpath, and this should be formed over the side ditch, as it is always better to have a drain under the footpath than under the road. In such a case it is always best to lay some kind of curbing and channeling at the side of the road, the nature of which must be determined by the locality, as when once down it costs less in such a situation to keep clean than anything else would. Small drains communi-

cating with the underdrains should be carried under the footpath at intervals, so as to carry off the surface water. All side ditches, outlets, borders, etc., should be thoroughly cleaned out and trimmed in the autumn, and gone over again where necessary in the spring. If this work is done in the summer it causes a great deal of useless trouble and expense, as the grass and weeds then grow so rapidly, necessitating the doing of the work over again. In addition to the side drains cross drains are necessary in most cases so as to thoroughly drain the center of the foundation of the road. These are usually pipe-drains and should communicate directly with the side drains, the fall from the center to the sides being from 1 in 80 to 1 in 100. In districts where stone is plentiful box drains are generally used, as being much cheaper. They are of square section, and are formed with flat stones for the top and bottom, and stone sides. The great advantage of these drains is that they can be so readily opened for cleaning by taking off the top stones. Sometimes it is advantageous to construct miter or V drains. They are formed as ordinary drains, but in the shape of a flat V, with the center uphill. In many instances a cheap and effective drain may be formed by cutting a trench about a foot square in the formation surface and filling it with large rough stones. The intervals at which these drains should be placed must depend on the nature of the subsoil and the quantity of water in it. With a clay subsoil they must be at shorter intervals than in gravel or sandy soil. Where there are footpaths, catch-pits or gullies may be used for the surface water, and should be connected directly with the cross drains. Any springs that may make their appearance must be immediately tapped and led away to the side ditches.

With a good system of cross-drainage there is no advantage in constructing longitudinal drains immediately under the water-tables in addition to the side drains. On roads which are formed on sidelong ground and benched into the hillside, it is nearly always necessary to have a drain in the side of the hill above the road to keep the land water from the road; but the form of this must be determined by local circumstances. A very common and inexpensive way is by cutting a deep trench and filling it with large stones. Whatever system may be adopted in such cases, the drains should be connected, at intervals, directly with culverts, so as to convey the water under the road and away from the upper side as quickly as possible. In many instances, particularly in hilly districts, no outlet can be found for the water on one side of the road. In such cases provision must be made for conveying it under the road at intervals by means of large drains or culverts. These are usually pipes of large diameter, or may be large box-drains, with the walls either built dry or with mortar; the larger ones being generally built with brick or stone walls, and with a turned arch similar to a bridge. In all cases an invert should be formed, either by an inverted arch or a flat pitched invert, or the walls would be rapidly undermined by the water. Barrel culverts, of circular section and built of bricks, are now rarely used. It will sometimes be found necessary to go to considerable expense to thoroughly drain a road, but in the end it will always be found to be most economical to do so, as a wet, undrained road is always most expensive to keep in good order. All underdrains and culverts, unless of very large size, should have an iron grating at the entrance, to prevent their getting choked with the rubbish which is always brought down at the commencement of a storm. It is essential that the cross-section of a road, when completed, shall be such as will allow the water to flow freely off it; yet care must be taken that it is not too round, or else the traffic will always keep to the center and form ruts, which will retain the water and thus cause great damage to the road by soaking into and thereby weakening it.

The best form for general purposes, I believe, for the cross-section is an arch of a circle, having a fall of 1 in 30 from the center to the sides of the road. A road should never be quite level longitudinally, or the water will stand in the gutters instead of flowing away freely; so that, even in quite level ground, it is better to go to a slight expense to obtain such a fall as will enable the water to get away easily. Steep gradients should be avoided where possible. No road should ever be made with a

gradient steeper than 1 in 30, but 1 in 50 is much better for general purposes, especially when practicable without much greater cost, for the after expense of maintenance will be much less. Great damage is caused to a road by the feet of the horses when drawing heavy loads uphill, and also by the drags on vehicles descending, by causing a disintegration of the surface. Much injury is frequently caused by water scouring the surface of a hilly road, sometimes the whole coat of surface metalling being swept away. When a road is formed by being benched into the hillside a retaining wall is frequently needed to prevent the earth falling on to it. When the cross-section of the road is formed partly by cutting into the hillside and partly by an embankment, a retaining wall will generally be needed on the other side also, and below the road. The section and strength of these walls must always vary very much, and must altogether depend on local surroundings and requirements. The width of a country road should never be less than 16 feet of metalled surface. On a road where there is great traffic the width should be such as will readily accommodate it, and, within certain limits, the wider a road is in proportion to the traffic the less it will cost to keep in good order. The formation surface of a road, when the drainage is completed, should be well rolled, so as to consolidate it, before the foundation is laid on it; the foundation is usually, in the case of streets or roads with heavy traffic, a pavement of rough flat stone set on edge and formed to the same cross section as the road will have when finished, the interstices being filled with small pieces hand-set with a hammer. Sometimes it is of concrete formed to a similar cross-section.

Cinders and slag form a very good foundation when obtainable, as does coarse gravel. In some districts, where stone is scarce, burnt clay is used; but for ordinary roads the foundation is most generally formed of rough stone, often of spalls from the nearest quarry. Whatever the foundation is it should be well rolled before the surface metalling is laid. Oftentimes the metalling is laid direct on the formation surface. The generality of existing roads are formed in this way, but it is not well to do so if it can be avoided, and the practice is much to be condemned. In some cases, when a road is laid on wet, boggy ground, a layer of fascines is laid first to form a firm foundation, and then the road is formed on it; but unless the nature of the ground is such as will always insure the fascines being kept in a wet or damp state they will soon rot and the road will go to pieces. Therefore they should never be used unless under unavoidable circumstances. In some districts the foundation is formed of chalk, but this should not be used unless it can be thoroughly protected from the action of wet and frost, owing to its power of absorbing water, which causes it to turn into mud in wet weather and to blow up in frost. Stiff clay is a bad foundation owing to its great contraction in dry weather and expansion in wet. When the foundation is laid, whatever course may be adopted, the metalling, if more than 4 inches or 5 inches in thickness, should be laid in two layers, each rolled separately, if rolled, as is frequently the case, with a heavy roller only. When two rollers can be used, one light and one heavy, the better course will be to roll it all in one layer, passing the light roller over first and finishing with the heavy one. The top layer, when partly consolidated by rolling, should have a binding material laid over the surface and rolled in with the metaling to form a compact mass, and while this is being rolled it should be well watered. It is better in making a new road to roll the surface, although the metaling is left in many places to consolidate by the traffic; but in such a case a great deal of material is wasted by grinding and crushing, besides causing great inconvenience to the traffic, and the metaling also wears round and takes a long time to set. Rolling is only necessary in the case of new roads, or when a thick coat of metalling is laid. When a thin coat is rolled the roller generally smashes a great deal of the stone, which would not be the case if it were consolidated by the traffic. Steam rolling is better and more economical than horse-rolling, as it more thoroughly and quickly consolidates the metaling. With a heavily weighted horseroller the stones are much displaced by the horses' feet, in consequence of the great exertion necessary to draw it. Horse rollers are very unwieldy in use and are

now seldom used anywhere. When rolling is resorted to in repairing a road it is sometimes necessary to stock the surface of it. This should not be more than half an inch deep, as deeper than that displaces the old metaling and increases the cost, with no corresponding advantage.

The metaling should be carefully spread and of a uniform thickness and the binding material applied when about half rolled. The binding is very often applied too soon and in too great a quantity, the consequence being that the road is soft and muddy and does not get firm until the superfluous small stuff is squeezed out and removed in the form of mud or dust by continued scraping and sweeping. The proper quantity of binding material which it is necessary to use is, in my opinion, as little as possible. Clean sharp sand or fine gravel is generally used as a binding material, but, as nearly all stone where rolling is resorted to is broken by machinery, I think the screenings from that are much the best material for such a purpose, and, being of the same nature as the metaling, will unite with it and form a hard, close surface, much better than with sand or gravel, which are of a foreign nature and, not being angular, like the screenings, will not set so readily. With a silicious material limestone screenings will cause it to set better than anything else. In all cases the screenings should be of the same material as the road metal. When using a binding material the fact is too often lost sight of that it is only intended to fill up the interstices between the larger stones, and when more than sufficient for this purpose is used the bad effects before mentioned always ensue. There is no economy in repairing a road with thick coats, and rolling, unless the traffic is very considerable, although there is a great deal more comfort to the public, owing to the easier draft; there will, moreover, be much less wear and tear of vehicles. A weak road should not be rolled, as although the weight of a 15-ton steam roller is very evenly distributed over the surface and the weight is not great per inch of width, it would be likely to be very injurious to the road, owing to causes which will be mentioned further on. When once a road is coated and rolled it is too often the case that it is left to take care of itself, except for scraping and sweeping, until it requires coating again. For some time before this is done the surface is covered with depressions, which are frequently of such a depth as to be dangerous. The coating would generally last much longer if, as soon as any hollow made its appearance, it were filled up with small-sized metaling. A proper system of repairing by small patches will in all cases result in a great saving.

One of the great causes of slacks or hollows appearing in the surface of a newly-rolled road is that the metalling has not been uniformly spread. When they appear during rolling they should be filled with metalling broken to a rather smaller gauge than the rest. The road should be carefully watched after the rolling is completed, and, if any hollows should appear then, they should be immediately covered with small patches of stone. Stone for patching should always be broken to a rather smaller gauge than for coating. Too great stress can hardly be laid on repairs by patching—a matter very imperfectly understood by a great many highway surveyors and in some towns never practised at all. Roads and streets have come under my notice where little or nothing is done to them until they require coating, and so coat after coat has been laid until the top metalling is 12 to 15 inches thick on roads with only light traffic. By this means the roads have been so raised that they are in the centre considerably above the level of the sidewalks and have a sharp and frequently dangerous fall toward the sides. The materials used for road metaling must of necessity vary very much according to locality. Owing to the cost of haulage local stone must generally be used, especially if the traffic be only moderate. If, however, the traffic is heavy, it will sometimes be found better and more economical to obtain a superior material, even at a higher cost; and, in cases where the traffic is very great, the best material that can be obtained is the most economical. In some cases the better material may be used on those parts of the road where the traffic is greatest, and, in other cases, in the centre of the road only. A good road metal should be hard and tough, and if it has a certain amount of binding nature in it so much the

better. It should also be able to withstand the influences of the weather. These qualities are seldom found together, as igneous and silicious rocks, although frequently hard and tough, do not consolidate so well nor so quickly as limestone, owing to the sandy detritus formed by the two first having no cohesion, whilst the limestone has a detritus which acts like mortar in binding the stones together

A stone of a good binding nature will frequently wear much better than one without, although it is not so hard. A limestone road of good cross-section will be more impervious to wet than any other, owing to this cause, and will not disintegrate so soon in dry weather, owing partly to this and partly to the well-known quality which all limestone has of absorbing moisture from the atmosphere. The limestones are generally not hard enough for roads with very heavy traffic, where hardness and toughness are of more consequence than any other properties. For such roads the best materials are some of the granites, such as Guernsey, Penmænmawr, and Cornish; Clee Hill stones, traps, basalts, whinstones, and some of the silicious rocks. For roads of moderate traffic the best are the harder limestones and a hard sandstone sometimes found in the coal measures. Iron and copper slag are sometimes used, but, although very hard and tough, have no binding property at all, and the edges of the pieces when broken are so sharp as to cut horses' feet very badly. In some parts gravel is used very largely for road metal. It should be well sifted from small material and the large stones broken down to the proper gauge. Field stone and river stone are much used in some districts, but generally make a rough road, as they are composed of the hardest parts of those stones which have resisted the action of the weather, and are, though frequently very hard, of unequal hardness, so that they wear very irregularly. Mere hardness without toughness is not of much use, as a stone may be very hard but so brittle as to be crushed to powder under a heavy load, when a stone not so hard, but having a greater degree of toughness, will be uninjured. The size to which surface metaling is generally broken is such that a stone in its largest dimensions will pass easily through a ring either of 2½ or 2¼ inches diameter. For roads where the traffic is light it may advantageously be broken smaller, as it will then cover a larger space, consolidate much more quickly, and make a smoother surface. When the material is rolled it need not be broken quite so small, as when it is set at once by rolling it is an advantage to have a rather larger stone, as it makes a stronger road.

Great care should be taken in the preparation of the material, so that the stones shall not be long, flat, or flaky; the small stuff should not be screened from it when hand-broken, as there is generally no more than what is useful. All clay and dirt should be separated from it, except in the case of gravel, when a certain proportion is necessary, for if gravel is too clean it will not set for a long time, owing to there being so many round stones in it. The stones should, within certain limits, be kept as nearly as possible of a uniform size and a cubical form, as they then make a better and more even road. Stone broken by hand is preferable to that broken by machinery, as machine-broken stone is not so durable as hand-broken. When broken by a machine it is always crushed to a certain extent by the jaws, and therefore does not wear so well, especially under heavy traffic; but when a machine can be kept in constant use it is often cheaper, especially if the stone is very hard; with some hard stone the cost will often be found to be only about half that of hand-breaking. A hard stone which is not tough and some of the softer stones will be crushed to powder by a machine. Machine-broken stone is also frequently very flaky, which is a great disadvantage in setting. In stone broken to a gauge of 2¼ inches the proportion of solid is 55 per cent. to 45 per cent. of void; therefore, taking the average weight of a cubic foot of solid limestone to be 170 pounds, the weight of a cubic yard of broken metaling would be 1 ton 2 hundredweight 2 quarters 4 pounds. This, when consolidated, would weigh nearly as heavy as the solid stone; in fact, a cubic foot of consolidated road metal weighs on an average of from 93 to 95 per cent. of an equal bulk of solid stone; therefore, it takes 1½ of broken material to form 1 of road, or, in other words, when the metaling is consolidated it occupies two-thirds of the space

it did before. The interstices in the road coating are filled with small stones and mud; these form a great portion of all roads. In a consolidated road the amount of metaling over seven-eighths of an inch varies from 20 to 55 per cent., and the mud from 20 to 25 per cent.; the remainder consists of small stone which is very useful in the road. In a road freshly coated, of course the proportion of large stone would be greater.

Generally speaking, the road which contains the greatest quantity of large stone will be the best; but sometimes such a road, from having an ill-drained foundation, will be very weak, and large quantities of stone may be put down without materially strengthening it, and the stones will always work about in wet weather. An excess of mud should not be allowed to accumulate, as few things tend to weaken a road so much; any road containing more than is absolutely needful should be constantly scraped until it is reduced to the proper quantity. The chief causes of wear on roads are the action of the traffic and the action of the weather. The relative wear of each can not be accurately told, as the one helps the other so much, and they vary according to local circumstances. On a strong consolidated road the greatest wear arises from the action of the horses' feet and the wheels of vehicles, and the smoother the road is the less the wear will be, as in a rough road, in addition to the downward pressure, there will be that pressure on every projecting stone which will tend to push it forward, and so cause a grinding movement between the stones. This pressure is greater in proportion as the diameter of the wheel is smaller, and is much more destructive than the vertical pressure. When the material is not thoroughly set this grinding movement is still more destructive and causes great wear and waste of material. On weak or ill-drained roads great wear is caused by bending and cross-breaking. When this takes place there is a yielding of the subsoil, as well as of the road coating; the road bulges and cracks under the weight of the load, the metaling is driven into the subsoil at the point of contact with the wheel, and that surrounding it rises above the level of the road; the surface water finds its way in through the cracks and weakens the road still more, and in frosty weather the frost gets in, and when the thaw comes the road is blown up in a great many places, and wet boggy places are formed which are very dangerous. Besides this the draft is very much increased on such a road, owing to the surface bulging before the wheels, and a horse is therefore, on a level road, continually pulling the road uphill. Along the sides of the ruts may be seen cracks, which lead directly to the subsoil. The wear caused by the wheels of vehicles is influenced very much both by their diameter and width. It has been said by some that the resistance to traction on a road is in inverse proportion to the square root of the diameter of the wheel. Others say it varies inversely as the diameter.

From experiments made with Easton and Anderson's horse dynamometer at the Royal Agricultural Show, 1874, a slightly greater ratio than inversely as the diameter was given, and I am inclined to think that inversely as the diameter is the more correct view of the two. There can, however, be no possible doubt but that large wheels are much more favorable both to draft and wear of the road than small ones. The draft is always much less on a smooth, hard, unyielding road; a flexible, yielding road, although it may be elastic, will not give back the force expended in the pressure of a wheel on it, and this force must naturally be more on a yielding than on a hard road. Of the width of a wheel, it may be said that up to a certain limit a broad wheel with the same load is less destructive to a road than a narrow one in about the following proportion—not, I believe, as is generally thought, in the direct ratio of its width. In practice, I think, a wheel 2 inches wide will be found to be nearly one and a half times as favorable to the road as a wheel 1 inch wide, a wheel 3 inches wide nearly twice as favorable, and a wheel 4 inches wide two to two and a half times as favorable. This will vary more or less under different circumstances, but will be found, I believe to be about the correct proportions. My reasons for so thinking will be found in the theory explained in the next paragraph. Practically, no advantage is gained by having wheels more than 4½ inches wide. Sir J.

Macadam said that the maximum load which should be allowed on any vehicle should be 9 hundredweight per inch of width of tire; Telford and Sir J. Macneil contended that 5 hundredweight was the greatest load that should be allowed, and I think their view is the more correct one, as few roads, except in large towns, are strong enough to bear such heavy loads as 9 hundredweight per inch continually passing over them. Broad wheels loaded in the same proportion as narrow ones are much more destructive than narrow ones. A road which will bear a considerable load on narrow tires will sometimes break down under the weight of a traction engine, although the pressure per inch of width of tire may be much less. I think the explanation of this may be found in the following theory: If we take a wheel 1 inch wide, and suppose that at the point of contact with the road surface (which we will suppose for the sake of illustration consists of spheres 1 inch in diameter) it presses on a sphere and that sphere on four others, and so on in a pyramidal form, it will be found that the weight is distributed over a much larger area of the subsoil than the surface it comes in contact with. Now take a wheel 4 inches in width, and suppose it rests on four spheres placed in a row, each 1 inch in diameter, it will be evident that each sphere can not rest on four independent spheres, and each pyramid will, therefore, be composed of parts of other pyramids, which intersect each other. With a 1-inch wheel, the sphere would rest on four others immediately supporting it, and the four spheres in a row under the 4-inch wheel would rest on ten; at the same depth four separate 1-inch wheels would rest on sixteen spheres, as against the ten supporting the one 4-inch wheel, and the lower we go the greater becomes the proportion in favor of the 1-inch wheels. Therefore, the greater the width of the wheel, loaded in the same proportion, the greater will be the pressure on the subsoil immediately under it, as the load is always borne by the subsoil and not by the road coating, which is merely a hard surface formed to protect the subsoil from the immediate effects of the traffic. Of course, this will be greatly modified in practice, owing to the different sizes and shapes and nature of the actual road coating.

It may, therefore, I think, be laid down that broad wheels with the same load are much less destructive than narrow ones, but broad wheels loaded in the same proportion per inch of width as narrow ones are much more destructive. The best shape for a wheel is cylindrical; dished wheels should never be used, as, owing to their shape, their line of direction is not the same as the line of draft, consequently a lateral motion is caused, which is a source of great injury to the surface of the road, especially in dry weather, and they also increase the draft. Wheels with tires the section of which is the segment of a circle are also to be condemned. In fact, all wheels which are not cylindrical have disadvantages for which they have no proportionate compensation. The effect of springs is more noticeable with vehicles going at a high rate of speed than when at a walking pace—in fact, when walking, the draft is very little less than without springs; at higher rates of speed the draft is much less. This applies to a smooth, hard road; on a soft, yielding surface the good effect of springs is considerably lessened. The weather has a considerable effect on the wear of roads, not so much directly as indirectly, by increasing the wear caused by the traffic. Excessive wet causes great wear by softening the binding in the road coating, which destroys the solidity of it and causes great wear by the material rubbing together, and makes it less able to support the traffic. Frost after wet causes great injury. The water in the road, and sometimes in the material itself, when frozen, bursts the road coating, especially if the foundation is wet, and when a thaw comes the road becomes rotten, and much damage is sometimes caused by heavy traffic coming on a road at such a time. Rain after a thaw also causes great injury, and when alternations of frost and thaw occur the road is tried very much; indeed, a good road will sometimes break up under such conditions. If the foundation is wet, and the frost reaches through to it, the road will be blown up from the bottom. Excessively dry weather causes great wear, especially with a siliceous road material, by the small stuff and mud being loosened; but this can always be counteracted by watering.

Dry weather has less effect on limestone than on any other road material. Trees and high hedges are also a great cause of wear by keeping the sun away, the road remaining wet where otherwise it would be dry. Wear is less, generally, in proportion as a road is smooth, strong, and well drained, and of a sufficient width to accommodate the traffic freely.

Many experiments have been made to measure the wear on roads; but this can only approximately be done, unless the area and quantity of material periodically laid are known. Some say that the wear increases in direct proportion to the traffic, others that it increases in a greater ratio; but from personal observation I think that, on a road where the traffic is very heavy, the latter idea is frequently correct. The amount of material expended annually in this country on main roads varies from about 40 cubic yards per mile in remote country districts to 1,000, and sometimes 1,500 cubic yards in the vicinity of large towns; but I think the general average would be from 70 to 80 cubic yards per mile. On district and parish roads it is frequently as low as 10 cubic yards per mile. A great mistake is often made in country districts where there is little traffic in procuring a very hard stone from a distance, when a moderately hard one can be obtained in the immediate neighborhood, and at a very much less cost. The hardest stone is not always the best for a road; it is only the best when the traffic is great. On a road where there is only light traffic a softer stone is much to be preferred, because the hard stones do not consolidate under the traffic, and the road is always rough and uneven. I have seen this in many cases, to make the matter worse, where a quantity of road scrapings was put on in the spring to make the stones set. When the wet weather came this was all squeezed out as mud and had to be scraped off again, causing great inconvenience to the traffic and costing altogether about twice as much as the local stone would have done. Where roads are repaired by thin coats without rolling, as all country roads must be, on account of the small quantity of stone used per mile, great care is necessary that none of the material is wasted. When the material is laid in the proper season—viz, in the late autumn or early winter, it soon consolidates under the traffic and forms a smooth surface. All the stone should be laid before Christmas except a small quantity which should be kept for the necessary patching in the spring. The coat should never be more than one stone thick; if it is necessary to put a greater thickness one coat should be laid and, when nearly consolidated, another should be laid on the top; by this means a much firmer and harder road is formed, and with less waste of material; but, when it can be avoided, a road should never be left to get so much out of shape as to require a greater thickness of metalling than one stone thick.

Before coating a road is commenced in the autumn all the small hollows should be patched, which will prevent them wearing larger; then those portions of the road which require coating should be done. It is always best to lay the coatings in short pieces, as if a long length is laid the traffic goes to the side of the road to escape the stones, and frequently cuts it up very much, whereas when laid in short lengths it is not worth while to go to the side to do so, as they are so soon passed over; if a long length of road requires coating it should be done in that way, and when the short coatings are worn in, which will not take long in the winter, intermediate coats may be laid. When the metalling is laid it should be constantly attended to, and raked so as to prevent the formation of ruts. Generally speaking, there is no advantage in stocking a road when repaired in this way; it may sometimes be necessary to do so slightly when the metalling is laid in a dry season, but this will always depend on circumstances. Ruts are best repaired by filling in the wheel tracks first, and when the material is partly set the center rut should be attended to; this is better than doing all three at once, or the center and one side first, as in the former instance intermediate ruts are soon formed by the traffic avoiding the loose stones, and in the latter the traffic all goes to one side, whereas if the two outside ruts are filled in first, the traffic keeps to the usual line on account of having the horse pad clear, and when it is time to repair this rut the traffic soon wears the single line of stones in. If it should be necessary to lay a large coating on a street or road with heavy traffic, a

binding material may be advantageously used, but, as a rule, a firmer road is formed without it. It is essential that the superfluous mud be removed from a road. This may be done by sweeping or scraping where it is in the form of either mud or dust. When dust is regularly removed from a road it does not require nearly so much watering in dry weather as it otherwise would; care must be taken, however, in a road composed of silicious materials that the road is not damaged by too much sweeping, as it will tend to disintegrate the surface, and a great deal of useful material is liable to be swept away. The best time for sweeping is early in the morning before the dew has dried, and there is much less inconvenience to the traffic at that time. Machines drawn by horses are sometimes used to sweep up mud or dust. The most common form is a circular revolving brush, mounted obliquely, which sweeps the mud or dust in a line on the one side, to be afterwards gathered up. Another machine often used is a scraping machine, constructed in an oblique manner also, and which acts in a similar fashion. This is very useful when the mud is partly dry. The most useful machine that I have seen is Warren's. In this machine a series of brushes attached to an endless chain revolves as it is drawn along, and sweeps the mud up an inclined plane into a mud cart, to which it is attached. When this cart is full it can be removed and hauled away, and an empty cart attached, so that the machine is kept constantly at work.

Some surveyors object to this machine on the ground that it removes too much of the useful small material, about the size of small shot, from the road. It does do so to a certain extent, but this can be reduced to a minimum by adjusting the pressure of the brushes, which is easily done by simply turning a small wheel; but the amount of small stuff that this machine removes is so little more than the ordinary kinds do, that it is much more than compensated for by the great saving in time and labor, besides more effectually cleansing the road. The great advantage of this machine is that it removes the mud quickly and at once from the road, and does not interfere with the traffic while doing so. These machines can only be advantageously used in or near towns, and where there is great traffic. In the country, hand scrapers and brooms are mostly used, but a small scraping machine which can be used by one man is of great advantage. The best way to use it is from side to side, as this tends to preserve the cross-section of the road. A man can scrape a great deal more in a day with one of these machines than with a hand scraper, and do the work much better. It is said by some to be very injurious to remove mud from a road when it is at all dry, but in most cases it is better for the road that it should be removed. A road should never be watered unless it really needs it, as too much water is very injurious and it increases the wear from traffic. To insure the constant attention that a road always requires, it should be divided into lengths, each under the charge of a constant laborer. As much should be given to each man as will keep him constantly employed during the summer, and he will be able to do all the necessary work at other times with the assistance of casual laborers. The length of road apportioned to each man will, of course, vary much according to circumstances; on main roads from 1 to 2 miles on a road with heavy traffic, to 6 and in some case 8 or 9 miles on roads with light traffic. On parish roads these lengths may in some cases be longer. The constant laborer should be on his road at all times, wet or dry, and it is of great importance that he should be there during heavy rain and storms so as to see that all drains and water courses are clear, as great damage is frequently done to a road by their being choked, particularly in hilly districts, where a great amount of rubbish is usually brought down at the commencement of a storm. The constant laborer should have entire charge of his length, under the surveyor. He should not have his work set by the piece, as piecework is seldom so well done as daywork, and he should not be moved from his length to another without good cause, as nothing causes a man to lose interest in his work so much as removing him when he has succeeded in getting his length into fair order. Some men can never be made good roadmen, while others acquire the necessary knowledge and skill very quickly, and will do more work and

make the material go farther than others who have been at similar work for many years.

It is generally much better to employ such men as these, even if paid a little more money, as it will be far more economical than employing the first man who applies for the work, as is very frequently done, because he will work for less money. This system of employing constant laborers has been in use on the South Wales County roads for the past 40 years and has been found to work very effectually; it has also been adopted in several parts of England during the past few years. I think it is a great mistake to let road repairs by contract; the work is never so efficiently done as it would be by day work, with men in charge of a skilled laborer, and when under the supervision of a surveyor. The only thing which can be advantageously let by contract is the supply of road materials, which may be supplied, ready broken, in heaps on the side of the road, or, better still, in stone depots recessed in the hedge or bank. It is better to have the material in small heaps, at short intervals, so that it can be wheeled out with a wheelbarrow, rather than have large heaps at long intervals and have to cart it where it is wanted; the men can usually make the material go farther in repairing and patching if accessible with wheelbarrows. It is best to have it supplied by the cubic yard rather than by the ton, and it should not be measured until broken and stacked. It should always be delivered by the end of the summer, as the road is less injured by the carting at that time, and the longer the stone is exposed to the action of the weather the better it is. If the repairs should be let by contract the term should not be for less than 3 years, as, if let for a shorter period than this, one man may keep the road in good repair for 1 year, and use a proper quantity of material and labor on it; the next year another man may get the contract, and do as little as he possibly can to it, just keeping it of good appearance until his contract expires, and then, as soon as wet weather comes, the road shows great signs of weakness and requires a great deal of material and labor expended on it to bring it into good order again.

I have not gone into the cost of labor or material in anything referred to in this paper, as they vary so much, even within a small radius, that such details would be of little practical value. The length of road which a surveyor can well superintend must depend to a great extent on the nature of the roads and the situation of them. It will be found more economical in all ways to have districts of such a size that a sufficient sum may be paid to a surveyor as will enable the authority to obtain a competent man and allow him to keep a horse. In this case he could look after a much greater length of roads if he had two or three assistants and a uniform system of maintenance over a larger area is much to be preferred to small divisions. Extraordinary traffic, as defined by the highways and locomotives (amendment) act, 1878, has caused a great deal of trouble and annoyance. It is frequently very difficult to tell what extraordinary traffic is, and when it commences. It is much to be wished that some clearer definition of what constitutes extraordinary traffic had been given in the act and that due notice of such traffic had been made compulsory, unless the traffic should be thrown on the road unexpectedly through an emergency. Such notice can not be reasonably expected until extraordinary traffic is more clearly defined. Extraordinary traffic thrown suddenly on a road, which is amply strong enough for the ordinary traffic of the district, will frequently destroy the surface of the road, often plowing down into the subsoil and cutting the road completely to pieces. In many cases, if due notice had been given of the intended increase in the traffic the road might have been strengthened so as to have borne it with little or no injury, and at a very much less cost than the after repairs which were required to bring it into good order. I think the abolition of turnpike trusts in England and North Wales was a great mistake, until some better method had been found to obtain funds for road maintenance. Then everyone who used the road had to pay for it, but now the burden falls almost altogether upon one class, viz, the farmers, especially in agricultural districts. From inquiries which I have made in South Wales (where turnpikes still

exist) at gates close to large towns, eleven-twelfths of the traffic which passes through them comes from the towns, and even at country gates, 6 or 8 miles from any town, three-fourths come from the towns.

It is manifestly unfair, then, that the county ratepayers should have to pay the whole amount for the maintenance of roads which are much more used by the townspeople than by themselves, and to this cause, I think, may be attributed the dissatisfaction which exists in the country as to the highways and locomotives (amendment) act, 1878. These remarks are intended to apply to main roads only, and not to district or parish roads. The inferior state of a great part of the main roads may also, I believe, be traced to the same cause. The greater part of most highway district boards is generally composed of farmers, and they naturally try to reduce the expenditure on the roads to as little as possible, and in many cases have done so to too great an extent, and the roads have suffered in consequence. The tendency is also to divide the present highway districts, which in many cases are already too small, and place each division in charge of a man who knows nothing whatever about road work, the salary offered being so small that no competent man could accept the appointment, a great many highway surveyors at present having had no previous training in road work whatever. I think this is a great argument in favor of the county government of roads. The districts should be of a large size, and the surveyors should be appointed by the county authority, and be required to devote the whole of their time to their duties. District boards would be required to regulate the expenditure, and I think it advisable that all main roads should be either under separate management, as in South Wales, or be inspected by an officer appointed by the county authority; or several authorities might combine to pay an inspector, and he should deliver an annual report on the state of the roads, and superintend the preparation of the estimates. Under the South Wales turnpike act, the main roads of each county are governed by a county roads board, with, in some counties, district roads boards, as distinct from highway district boards, to regulate the expenditure. The surveyors have charge of the main roads only. The highway district surveyors are also appointed by the county roads boards, although not paid by them, and they have charge of the district and parish roads. Until recently, the main roads were annually inspected by a general superintendent of roads for South Wales, appointed and paid by the local government board. This office has recently been abolished, as the loans advanced by government to the respective county roads boards when the act was passed, have been repaid.

In many of the English counties the main roads are inspected; but in many cases it is either by magistrates, county surveyors (who are usually architects), or police superintendents, etc. These may know very well when a road is in good or bad condition; but they can not know, unless they have had special training, what is the most economical and best way of repairing a good road and maintaining its efficiency, or of repairing and making good a bad one. A great deal has been said lately as to how funds should be obtained for the maintenance of roads if the present system of rating should be abolished. In my opinion, the fairest way would be by the appropriation of the carriage tax, and if that did not prove sufficient, by the reimposition of the horse-tax. All vehicles and horses, whatever they may be kept and used for, should be taxed. In the case of vehicles, the tax should be adjusted on the basis of the tolls which were levied under the turnpike act, due regard being paid to the size and shape of the wheels. It may be said that in this case the townspeople would have to pay towards maintaining the country roads, whilst the country people would not pay anything towards the maintenance of the town roads and streets; but I think this objection may be met by providing that the tax should be divided proportionately and applied to both purposes, certain of the streets for this purpose being classified as main roads. Since the preceding paper was written, now nearly 5 years since, the local government act, 1888, has been passed, and in clause 20 it provides that all local taxation licenses, as specified in the first schedule to the act, are to be paid into the Bank of England to an account called the local taxation account, after

which, when the respective amount collected in each county has been ascertained and certified by the commissioners of inland revenue, it is to be paid, under the direction of the local government board, out of the local taxation account, to the county counsel of each county.

This schedule, in addition to others, includes licenses for carriages, trade carts, locomotives, horses and mules, and horse-dealers; and in section 121 a temporary provision is made by which, in addition to part of the probate duties, all duties on these licenses under any act of the present session are to be applied as a grant, to be distributed as follows: "In paying to every county, highway, and other local authority, who have heretofore received out of moneys provided by parliament a contribution to the cost of roads, or to the successors of such authority, sums calculated in like manner and according to the like scale and regulations as in the financial year ending on the 31st day of March, 1888." A great outcry has been made against the projected wheel-tax (withdrawn since this paper was read); but it was only to be expected, as people who have previously benefited by the taxation of others do not care to have the burden thrown directly on their own shoulders. The usual argument against it is that the roads are for the indirect benefit of all. This is quite true; and, therefore, all the more reason why some more equitable mode of obtaining funds should be provided than at present exists, by which the whole cost of maintaining the county main roads is thrown chiefly on the agricultural classes. I strongly hold that those who obtain a direct benefit from the use of the roads should pay directly towards the cost of their maintenance. At present it is difficult to judge how the act will work in relation to main roads. In South Wales, all tolls will be abolished from the date it comes into operation, and funds for their maintenance will be obtained in a similar manner as in England and North Wales. The general opinion in South Wales is that under section 11, clause 2, the various urban authorities will take possession of the various lengths of road within their districts, thus leaving many short isolated lengths, which will be transferred by the county councils to the various highway districts under clause 4 of the same section. The proper maintenance of all these roads will be supervised by the road surveyors of the councils of the different counties, and all payments to the bodies who have taken over these roads will be made on their certificates. It seems probable that the district roads there, which stand on a somewhat similar footing to the main roads in England, and receive a contribution from the common fund of the county, will all be declared main roads under the act. No special provision has been made to meet this as far as I can see, but it seems to be the evident intention of the act. In England a similar course seems likely to be taken as regards the absorption by urban authorities of main roads in their districts. The proper supervision of the main roads seems well provided for by the act, as by clause 5, section 11, no county council has power to make any payment to a district council in respect of the maintenance, repair, or improvement of any road by an urban authority until the county council is satisfied by the report of their surveyor or such other person as they may appoint for the purpose. While the more efficient control and maintenance of the main roads appear to be well provided for, the importance of the proper maintenance of district and parish roads should not be lost sight of.

MANCHESTER DISTRICT.

BLACKBURN, BOLTON, SALFORD, AND STRETFORD.

REPORT BY CONSUL GRINNELL, OF MANCHESTER.

I inclose herewith three interesting reports received from the borough surveyors of Blackburn, Bolton, and Salford, in this consular district, in reply to my inquiries as to the making and maintenance of city streets within their municipalities. I would draw especial attention to the excellent report, with inclosures, furnished me by Mr. J. B. McCallum, the borough and water engineer of Blackburn. I also inclose a report received from the surveyor to the Stretford local board.

I have delayed the sending forward of these reports in the hope of being able to obtain similar information from the borough surveyors of Manchester, Oldham, and Lancaster, but I regret to say that these gentlemen have not seen fit to reply to my letters of inquiry.

WILLIAM F. GRINNELL,
Consul.

UNITED STATES CONSULATE,
Manchester, June 18, 1891.

BLACKBURN.

Borough and Water Engineer McCallum to Consul Grinnell.

BOROUGH AND WATER ENGINEER'S DEPARTMENT,
Municipal Offices, Blackburn.

WILLIAM F. GRINNELL, Esq.,
United States Consul, Manchester:

SIR: In reply to your letter, I beg to hand you the following information which I trust may be of some use:

(1) The methods employed in making and maintaining the city streets.

After due notice has been given owners of property (see copy, inclosure No. 1), new streets are made by the corporation and the cost charged to owners of the property abutting on same, according to length of frontage. Materials are purchased by the corporation under annual contracts, and labor is done by contract, prices being arranged for each street separately. When completed, the streets are maintained by and at the expense of the corporation, both under annual contracts and by day labor.

(2) The details of the systems followed and expenses incurred by that branch of the city government having in charge the city streets.

Granite sets, 5 inches deep, with tar joints on a bed of cement concrete 6 inches thick, costing 11*s*. 6*d*. per square yard.

Granite sets, 5 inches deep, with tar joints, on hand-pitched under-bedding stone, 12 inches thick after being rolled with a 15-ton steam roller, costing 8*s*. per square yard.

Local stone sets, 6 inches deep, with tar joints, on hand-pitched under bedding stone, 12 inches thick after being rolled with a 15-ton steam roller, costing 6*s*. per square yard.

Local stone sets (seconds), with tar joints on 10 inches of clinkers and mill ashes, costing 5*s*. 6*d*. per square yard.

Granite hand broken to pass a 2-inch ring, on hand-pitched underbedding stone, 12 inches thick after being rolled with a 15-ton steam roller, costing 4*s.* per square yard.

Limestone, ditto, costing 3*s.* per square yard.

Footways: Granite curbs, 12 inches wide and 7 inches deep, with local flags 3 inches thick, mortar joints, and gravel underbedding 3 inches thick, costing 7*s.* 3*d.* per square yard.

Local stone curbs, ditto, costing 5*s.* 9*d.* per square yard.

(Specifications for materials and labor inclosed. Inclosure No. 2, Forms Nos. 1, 2, 3, 5, 6, 7, 8, 29, 33, and 34.)

(3) The materials used for streets of heavy and light traffic, respectively.

Heavy traffic streets: Granite sets on cement concrete. Granite sets on hand-pitched underbedding.

Light traffic streets: Local stone sets on hand-pitched underbedding.

Back streets: Local stone sets (seconds) on clinkers and mill ashes, run in with tar.

Macadamized roads: Granite or limestone, hand broken, on hand-pitched underbedding.

(4) The source and treatment of such materials, and the first and final cost.

Granite sets, costing 22*s.* 6*d.* per ton, and curbs, costing 4*s.* per lineal yard, are obtained from Dalbeattie, Scotland, or Newry, Ireland. (See inclosure No. 3, giving the results of experiments to ascertain the resistance to thrusting stress and the porosity of Dalbeattie gray granite.)

Granite macadam from Penmaen-Mawr, Wales, at 11*s.* 3*d.* per ton; local stone sets at 11*s.* per ton; curbs at 2*s.* 6*d.* per lineal yard; flags at 3*s.* 4*d.* per square yard, and underbedding stone at 1*s.* 8*d.* per ton, are obtained from the Rossendale Valley, Haslingden, Darwen, Blackburn, etc. About 6*d.* per ton and 3*d.* per yard is added to the above prices in order to cover office and stoneyard expenses. (See inclosure No. 4 for description of Penmaen-Mawr stone.)

(5) The cost of building and maintaining such streets, and the assessment of such first cost and maintenance.

Cost of making, 6*s.* 6*d.* to 12*s.* per square yard. Cost of maintaining, 8*d.* to 1*s.* 3*d.* per square yard.

Assessments.—First cost is paid by property owners. Streets are maintained by and at the expense of the corporation. An annual sum, amounting to about £7,000 is set apart for repairing streets, etc., and £4,500 for repairing macadam roads.

Very faithfully yours,

J. B. McCallum,
M. Inst. C. E., Borough and Water Engineer, Blackburn.

THE BLACKBURN IMPROVEMENT ACT, 1882.

[Inclosure No. 1, in letter of the borough surveyor of Blackburn.]

Whereas, The street called Henry street, from James street to Regent street, within the borough of Blackburn, not being a highway reparable by the inhabitants at large, is not sufficiently sewered, drained, leveled, flagged, paved, channeled, metaled, made good to the satisfaction of the corporation of Blackburn,

The corporation do therefore hereby give you notice to sewer, drain, level, pave, flag, channel, metal, and make good in the manner specified in the specification, hereunto annexed, so much of the said street, as the premises belonging to you and each of you severally and respectively front, adjoin, or abut upon, within 60 days from the service hereof:

And further, that a plan and section showing the particulars of the said works are deposited at the office of the borough surveyor, within the municipal offices, in the said borough, for inspection; and the same can be inspected between the hours of 9

o'clock in the morning and 1 o'clock in the afternoon on Saturdays, and between the hours of 9 o'clock in the morning and 6 o'clock in the evening on any other day, excepting Sunday; and the borough surveyor, upon application, will give such further information as may be needed, or you may require:

And further, that the highway and general drainage committee of the corporation will meet at the committee room in the town hall, in the said borough, on Monday, the 16th day of February, 1891, at 3 o'clock in the afternoon, for the purpose of considering any objections which may be made against the proposed level of the said street, when and where all persons interested therein or likely to be agrieved thereby may attend:

And further, that in case of your default in the premises, the corporation will, without further notice, execute the said works (except any which, at such meeting, may be ordered to be abandoned, and with such alterations, if any, as at such meeting may be ordered to be made) and charge you with the expenses thereof.

Dated this 15th day of January, 1891.

J. B. McCallum,
Borough Surveyor.

To the Blackburn school board, and William Ditchfield, clerk; to the North Britons' Friendly Society, and John Sefton Scott, their secretary; and to Thomas Brindle and Charles Augustus Sanderson, Thomas Howson, and William James Waugh, the executors of the late Thomas Ainsworth; or others, the owners or occupiers respectively of the lands abutting upon Henry street aforesaid.

Specification referred to in the foregoing notice.

To excavate the ground and form and lay a sewer or sewers along the above-mentioned street of glazed earthenware socket-jointed pipes, of the sizes and to the inclinations, depth, and length as shown on the plan and section, and connect the same to the nearest main sewer. Manholes and ventilating shafts to be constructed where shown of 9-inch brickwork in cement, with step irons built in at intervals of 1 foot; the bottoms being formed of blue radiated bricks floated in cement, and the tops arched over and covered with 6-inch landings and cast-iron lids of approved pattern.

Branch drains to be laid for all existing or future requirements as the borough surveyor may direct. Each pipe must be boned to an uniform inclination, and the joints made water tight with clay puddle or cement.

Earthenware or cast-iron gullies and grates to be fixed in the position shown on plan and connected to the sewer by 6-inch earthenware pipes. The gullies to be of the form and dimensions of the sample gullies and grates lying for inspection at the storeyard of the corporation at Islington.

The down-spouts to be connected to the sewer with 4-inch pipes; such down-spouts as require it to be lengthened for this purpose.

The carriageway of the before-mentioned street must be excavated to the depth and extent shown upon the plan and section, and a formation or underbed composed of broken stones, hard bricks, or other clean and approved material, must be broken to the satisfaction of the borough surveyor or his inspector. The underbed to be laid in the manner shown upon the section, and to be of such depth that it shall average 12 inches in thickness after being consolidated by a steam roller. The underbed to be then covered with a layer of clean, sharp, screened gravel, 2 inches in thickness, and properly prepared for the paving.

The flags, curbstones, and sets must be of good quality, and such as shall be approved by the borough surveyor.

The flags must each contain an area of not less than 5 square feet, and be at least 3 inches in thickness, well squared through, laid with close joints, in good lime mortar, on a bed of gravel not less than 3 inches in thickness.

The curbstones must be in lengths of not less than 2 feet 6 inches each, 7 to 8 inches deep, and 12 inches broad, well dressed, squared and jointed, and properly laid to the inclination shown on this section.

The carriageway of the street must be paved with what are known as 6-inch sets, squared and laid in courses of equal breadth, well and firmly bedded in the gravel. The joints between the courses not to exceed half an inch, to be well filled with clean chittings screened, when required, to free them from dirt or sand. The paving to be well rammed with proper beaters and the joints run with impervious material.

By permission of the borough surveyor, a mixture of sharp sand and clean mill ashes may be used instead of gravel when the state of the weather or the nature of the ground seems, in his opinion, to require such; and when this mixture is used it must be prepared by thoroughly blending equal parts of sand and ashes.

DALBEATTIE GRANITE.

DALBEATTIE, SCOTLAND, *February* 11, 1891.

I. B. McCALLUM, Esq., C. E.,

Borough Engineer, Municipal Offices, Blackburn:

SIR: We regret we have kept you waiting so long for the information required, but our friend was late in replying, and, after all, his reply was not satisfactory.

We take the following extract from "Granites and our Granite Industries," by Geo. F. Harris, T. G. S., published by Crosby, Lockwood & Co., London, in 1888:

"*Dalbeattie quarries.*—The light-gray stone obtained from these quarries is fine-grained, some kinds approaching medium. The quartz is white, clear, and transparent. The feldspar is mostly white also, but here and there assumes a light-brown tint. None of the crystals are well defined, and they are much interlocked with the quartz. There is a fair proportion of black mica present, and another black mineral, which occurs in long needle-like crystals, denotes the presence, perhaps, of schorl. This last mineral is not abundant. The stone appears to be very hard, compact, and takes a beautiful polish, being highly suitable for ornamental decorations and the like."

Perhaps this, together with a copy of the crushing and porosity tests made by Kirkcaldy & Son, of London, which we inclose herein, may answer your purpose; but if not, please inform us and we will do what we can to procure further information.

Yours respectfully,

P. PRO., D. H. & J. NEWALL,
H. GILLISPIE.

Results of experiments to ascertain the resistance to thrusting stress of four 4-inch cubes of granite received from Messrs. D. H. & J. Newall.

Test No.	Name of quarry and marked.	Dimensions.	Base area.	Cracked slightly.			Crushed, steel yard dropped.		
				Stress.	Per square inch.	Per square foot.	Stress.	Per square inch.	Per square foot.
V.		*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Tons.*	*Pounds.*	*Pounds*	*Tons.*
891	Dalbeattie gray granite.	4.00×4.00×4.00	16.00	176,500	11,031	709.3	241,870	15,116	972.0
889	....do....	3.96 4.00×4.00	16.00	174,800	10,925	702.5	240,180	15,011	965.8
888	....do....	4.00 4.00×3.97	15.88	168,200	10,591	681.0	212,640	13,390	861.0
890	....do....	3.97 3.98×3.98	15.84	164,900	10,410	669.4	202,230	12,767	821.0
	Mean	....	....	171,109	10,739	692.5	224,230	14,071	904.8

Bedded between pieces of pine ⅜-inch thick.

DAVID KIRKCALDY & SON.

99 Southwark street, London, S. E., March 25, 1886.

Messrs. D. H. & J. NEWALL,

Dalbeattie Granite Works, Dalbeattie, Scotland.

Experiments to ascertain the porosity of two pieces of stone from quarry, as under.

[Weighed when thoroughly dry and weighed again after 10 days' immersion in water tank.]

Received from—	Name of quarry and marked.	Test No.	Porosity percentage of original weights.			
		V.	Before.	After.	Diff.	Porosity.
			Pounds.	*Pounds.*	*Pounds.*	
Messrs. D. H. & J. Newall..	Dalbeattie gray granite..	892	23. 14	23. 15	0. 01	·00
		893	23. 76	23. 77	0. 01	·00

For results of experiments under Thrushing Stress. (See report of March 25, 1886.)
99 Southwark street, London, S. E., March 8, 1888.

DAVID KIRKCALDY & SON.

Messrs. D. H. & J. NEWALL,
Dalbeattie Granite Works, Dalbeattie, Scotland.

PENMAENMAWR (WALES) STONE.

The Penmaenmawr stone possesses very slight porosity, the absorption being less than 0.03 per cent. of its weight, an important characteristic as regards disintegration by atmospheric influences, or by chemical action consequent upon contact with animal droppings or other street refuse, or by the action of frost, stones of slight porosity being best able to withstand such actions.

From Messrs. Brundritt & Co.'s quarries.

Silicia	56. 25
Alumina	18. 02
Peroxide of iron	3. 81
Protoxide of iron	3. 70
Oxide of manganese	Trace.
Lime	6. 90
Magnesia	5. 04
Potash	2. 76
Soda	1. 90
Carbonic acid	0. 50
Sulphuric acid	0. 03
Combined water	1. 09
	100. 00
Specific gravity	2. 76

The crushing strength is placed at 26,837 pounds per square inch.

BOLTON.

Borough Surveyor Brockbank to Consul Grinnell.

BOROUGH SURVEYOR'S OFFICE, *Bolton.*

SIR: In reply to your letter as to street building and road making, I have pleasure in forwarding the following particulars referring to our own town:

The owner of any land desiring to open out the same for building purposes is re-

quired to provide front streets of not less than 12 yards wide and back streets of not less than 6 yards wide, which are sewered, formed, paved, flagged, etc., at the expense of the owners of the property abutting on same. In forming the roadway is excavated to a depth of 2 feet in front streets and filled in with 14 inches of ballast, back streets being excavated to a depth of 18 inches and filled in with 8 inches of ballast, and both back and front streets are paved with local grit sets of 8 inches deep. The footpaths are excavated to a depth of 6 inches and filled in with 3 inches of cinders or gravel and flagged with flags of not less than 3 inches thick in both front and back streets, the edgings and curbs being 8 inches deep and 12 inches wide in front streets and 12 inches deep and 6 inches wide in back streets.

The cost of excavating, forming, paving, etc., is as follows: Excavating, 1*s.* 6*d.* per cubic yard; 14 inch ballasting, 8*d.* per superficial yard; 8 inch ballasting, 6*d.* per su-superficial yard; paving, 3*s.* 2*d.* per superficial yard; flagging (front streets), 4*s.* 5*d.* per superficial yard; flagging (back streets), 3*s.* 9*d.* per superficial yard; edgings (front streets), 2*s.* 11*d.* per superficial yard; edgings (back streets), 2*s.* 3*d.* per superficial yard; curbs (front streets), 3*s.* 2*d.* per superficial yard; curbs (back streets), 2*s.* 6*d.* per superficial yard.

Public streets reparable at the expense of the corporation where there is heavy traffic are mostly paved with granite sets, and, unless the foundation is good, on a concrete bed of 6 inches deep. These sets are obtained principally from Wales and are 6 inches deep and 3 inches wide, their average life being about 30 years and the cost as follows: Concreting, paving, and asphalting 11*s.* 8*d.* per superficial yard, and will require repaving once during the time stated, at a cost of 3*s.* 6*d.* per superficial yard, making an average cost for the 30 years of 6*d.* per superficial yard per yard; paving and asphalting, 9*s.* per superficial yard, and require repaving twice at a cost of 3*s.* 6*d.* per superficial yard each time, thus giving an average for the 30 years (without concrete) of 6½*d.* per yard per year.

Leicester Mill sets of 8 inches deep are obtained in Lancashire and will last 8 years where the traffic is heavy, the cost of concreting, paving, and asphalting being 9*s.* 2*d.* per superficial yard; they require repaving once at a cost of 2*s.* 3*d.* per superficial yard, making an average for the 8 years of 1*s.* 5*d.* per superficial yard per year. Paving and asphalting without concrete will cost 6*s.* 6*d.* per superficial yard, repaving once at a cost of 2*s.* 3*d.* per superficial yard, thus showing an average for the 8 years of 1*s.* 1*d.* per superficial yard per year.

Local grit sets of 8 inches deep, obtained from local quarries, will last 4 years with heavy traffic, and concreting, paving, and asphalting will cost 7*s.* 2*d.* per superficial yard per year; without concrete the cost will be 4*s* 6*d.* per superficial yard, or an average of 1*s.* 1½*d.* per superficial yard per year.

Yours faithfully,

W. H. Brockbank,
Borough Surveyor.

William F. Grinnell, Esq.,
United States Consul, Manchester.

SALFORD.

Borough Engineer Jacob to Consul Grinnell.

Borough Engineer's Office,
Town Hall, Salford.

Sir: I have the honor to acknowledge receipt of your communication, and below I give you the information you require.

The "methods employed in making and maintaining the city streets," do not differ in any essential respect from the instructions contained in any of the ordinary text books on road making, but it is needless to state that the making of a street and its

maintenance, are two wholly different and distinct matters. The preparation of the foundation of a new street, to be constructed on new ground, consists of forming the ground to the same contour as that of the street when finished, and the writer can not do better than inclose one of the standard drawings which he has designed for use in his office at the Salford town hall. This section is for a new paved road, the only variation being that in localities where the traffic is very heavy, paving sets of Welsh, or other good granite are employed for the surface of the carriageway, whilst the carriageways for streets to carry lighter traffic the surface is paved with sets of somewhat larger size, of the millstone grit, which are produced principally from north Lancashire, near Stacksteads or Darwen. The life of millstone-grit sets under a fair average traffic, does not generally exceed fifteen years, whilst the paving stones of Welsh granite may be expected to stand on a good solid foundation for 25 or even 30 years. It is therefore needless to say that a high rate of carriage upon the material will be warranted where such a durable material as granite is employed.

It is of the first importance that the foundation of a street should be disturbed as little as possible either by main drainage, cross-drainage, or the laying of gas and water pipes, for foundations that have been much disturbed are pretty sure to settle more or less in process of time, causing dislocation of the sets or other surface materials, and a bad surface for traffic. The writer is of the opinion that in North America or Canada where the climate is excessive, it is desirable that all roadways should have a solid foundation of not less than 10 or 12 inches of cement concrete, laid beneath the paving sets, for even in the Manchester and Salford streets, the sets of which are laid on a layer of cinders, it is no uncommon thing to observe that during a severe frost the whole surface of a street will rise from the foundation and become detached on account of the frosts penetrating to the damp cinders under the sets and lifting them up bodily out of their place.

It would be extremely difficult to supply a reliable estimate of the cost of street-making, even in England, unless the nature of the material to be employed were specifically defined, and the locality from which it is to be obtained. The distance from which materials are procured forms an important factor in framing the estimate of cost, and a small increase in the distance from which materials have to be brought will sometimes double the cost of the work, but it may be some guide to say that 1 ton of Welsh granite sets will cover about 3½ square yards of surface, whilst 1 ton of grit sets will cover an area of 4 square yards of carriageway. In almost every locality in or near Manchester, the footways are flagged with the best self-faced—that is, natural faced—flags of millstone grit, truly squared and laid in courses across the footway, no flag to be less in area than 3 square feet, and none more than 12 square feet in area. The curbing for the footways is of millstone grit, laid in lengths of from 2 feet 6 inches to 3 feet. The stones are 10 inches wide by 7 inches deep, laid flat.

Yours obediently,

ARTHUR JACOB, B. A., M. I., C. E.,
Borough Engineer.

WILLIAM F. GRINNELL, Esq.,
United States Consul, Manchester.

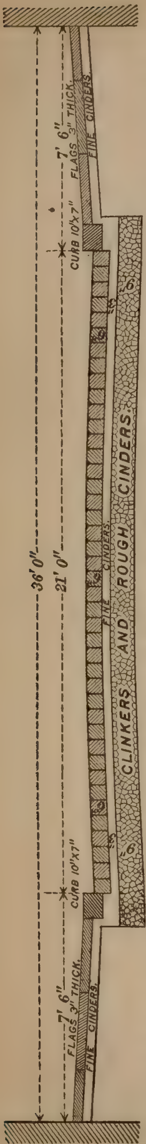
STRETFORD.

ENGINEER ROYLE TO CONSUL GRINNELL.

SIR: In answer to your inquiries respecting road-making in this district I have much pleasure in contributing the following information:

(1) The methods employed in making and maintaining the public roads.

In this local government district of Stretford which is situated on the southwest side of the city of Manchester, we have two main thoroughfares which converge at a



Transverse section of street in Salford.

point half a mile from the city boundary, through which a very large and heavy traffic of agricultural produce finds its way into the Manchester markets, as well as other general and through traffic of building material, etc., and during portions of the year the traffic continues through the night. This road is the old Roman road from London and Chester to the north. The length of this main road is 4 miles, and with the exception of half a mile the center portion, 16 feet wide, is paved with granite setts, which form the road way on which the tramcars run, the sides thereof being a macadam surface. The original way of making this road was that known as MacAdam's system, viz, by simply tipping and spreading broken stone on a moderately level surface and thus forming the roadway, the thickness of broken stone or metal varying from 3 to 6 inches. We have no broken stone roadways made on the Telford system, but I have some made by first excavating the carriageway 18 inches in depth below the side curbs. The foundation is then formed with 10 inches of cinders or furnace slag, on which is placed 4 inches of rough gravel, and the final or finished surface with 4 inches of hard stone (trap rock), broken to a 2½-inch gauge, the steam roller having been used during the making and up to the final completion. A roadway made up in this manner gives every satisfaction.

(2) The details of the systems followed and expenses incurred by that branch of the local government having in charge the public roads.

In the maintenance of MacAdam or broken-stone roads the method adopted is to use the hardest and most durable stone obtainable, and before laying on the stone the surface is hacked up with picks in cross courses about 4 inches apart in order to burst up the old material, then one, two or three stones in thickness of broken stone is laid on evenly, the steam roller being used before the gravel is put on for a binding material. The road is then watered as required and finally consolidated with the roller until completed. Two men are required to constantly brush in and spread the binding material and distribute the water until the surface is thoroughly creamed up. The rolling should be done slowly, as nothing is gained by a rapid motion, the fuel consumption being considerably increased without any advantage to the work.

Macadam or broken-stone roadways in Stretford are very expensive to maintain, in consequence of their close proximity to Manchester, and the average cost per mile for watering, scavenging, and repairing is about £360, notwithstanding the central portion, which is paved with granite, being maintained by the Manchester Carriage and Tramways Company.

The material put on the roads is from the quarries at Penmaenmawr, in North Wales, and is of the igneous or trap rock formation. It is very hard and durable, there being no better stone for the purpose. It is broken to a guage of 2½ inches (if the roller is not used it should be broken to a 2-inch gauge), and the cost per ton when broken and on the wharf is 10*s*. 3*d*.

(3) The effect of improved public roads upon land values and other economic conditions.

I can not give you any information in regard to this question,

except that there can be no doubt that good roads increase the value of land through which they pass for many purposes besides those for building, just in the same manner as main outfall sewers improve land for building purposes and the development of estates.

Yours, respectfully,

H. ROYLE,
Assoc. M. Inst. C. E.

WILLIAM F. GRINNELL, Esq.,
United States Consulate, Manchester.

TUNSTALL.

REPORT BY CONSUL BURGESS.

HIGHWAYS.

As we look into the subject of roads and road-making in this consular district we find a wide and interesting field for study. Looked at from an historic standpoint, the subject at once brings us to the time of the Romans—the world's great highway builders—at the time of the conquest by them of the islands of Britain towards the end of the first century. One at least of these old roads runs through this district.

It is not, however, from this point of view, extremely interesting though it be, that I propose to report my investigations of the very practical and important question of how roads are made and maintained within my circle of observation. The subject naturally divides itself into two heads, viz, the country roads and the city or town streets. These again subdivide themselves in the highways and country lanes; and the main roads and bye-streets.

The beautiful country roads now in use, for which these middle counties of England are so worthily famous, were, with the exception of the few roads built since 1878, made by the turnpike trusts under special acts of Parliament, the first of which was passed in 1762. The different districts of the country, having been divided into sections or divisions, each several section was placed in the hands of trustees, separate and distinct acts of Parliament being required for each of said sections. These trustees levied tolls on all traffic passing over the roads under their control; the amount of toll demanded, per horse, cart, wagon, etc., varied from time to time, according to the distance traveled between the toll gates and the amount expended in building and maintaining the roads. In some instances the trustees, finding the revenue from their roads inadequate to meet the outlay, delegated, or contracted out, to private individuals, the collection of the tolls. These individuals, having guarantied the necessary amount to the trustees and depending for their reimbursement on the tolls, looked very sharply after the just and full collection of the same.

Under these trusts many of the old lanes and wagon tracks, by the proper use and periodic application of hard broken stones (obtained from the adjoining counties) to the ruts and holes caused by continued travel, have attained a condition equal to the highways running through the country. To the good judgment and judicious care of these trusts is due the present almost perfect condition of the main or country roads of England. Many years, however, of untiring labor have been required to accomplish such results.

These trusts, however, were abolished in this district about the year 1878. From that date to the year 1888 the roads were under the control of, and maintenance of the same devolved upon, the local authorities.

At the present time the county council, who occupy in general the position of our county boards of chosen freeholders, or county commissioners, have the entire oversight and control both of the building and maintenance of the country roads. A county surveyor is appointed by them, who is a paid officer, devoting his entire time and attention to the one subject of roads, laying out and constructing new ones and keeping in repair the old, and buying all the materials necessary thereto.

The county is divided into districts and the detail of the road work is looked after by assistant surveyors.

The money required for the proper maintenance of the highways, outside the town limits, is derived by a precept issued periodically by the county commissioners to the various town authorities, demanding the amount which has been expended on the roads in their locality. This amount is collected by the town authorities in the general town rates, or taxes, the rate for this purpose now being 3 farthings on the pound, or about $\frac{31}{100}$ of 1 per cent., and are levied on the estimated rental value of the property and paid by the occupier, be he the owner or only a leaseholder.

The cost of keeping these country roads or highways in proper order necessarily varies greatly according to the locality and according to the amount of traffic passing over them. The Stafford County council estimate the annual cost to be from $150 to $500 per mile. The road-beds are not only kept in order, but the road-sides are kept clean and free from grass and weeds. The loose stones are gathered and the mud and dust is more tenderly cared for than is the case in many of our larger towns.

STREETS.

The term main roads in this district indicates the chief streets or thoroughfares within the town limits.

The local governing bodies, be they the town council of an incorporated borough or the local governing board of an unincorporated place, have the power granted to them to maintain and repair the main roads

within their boundaries. The county surveyor, however, has an oversight of all this work, and if he certifies that the roads have been kept in proper repair the county council annually reimburse the local bodies for the expenditure they have made.

The kind of roadbed in general use in this district is that so well known by name in the United States, as the "macadam road," and yet so often disgracing the name on account of the cheap and incomplete manner of its construction. The construction of the roadbed here is very thorough, the extent of the excavation depending upon the nature of the soil. Two feet is the usual depth to which this excavation is made, but should the soil prove loose or of a nature unsatisfactory for a good foundation a still greater depth is reached. A layer of hard broken bricks or the refuse from the many potteries of this neighborhood, such as cinders, broken ware and saggars, or any other hard refuse material is put down to the depth of about 18 inches. The contour or rounded shape of the road is roughly formed in this state, the mass being consolidated by means of steam or heavy horse rollers. The former are generally used and of course are much preferred on account of their great weight, the standard weight being 12 tons. The next 3 or 4 inch layer consists of granite stone of the best and hardest quality, broken into pieces capable of passing through a 3-inch gauge. The mass is again rolled. The finishing coating of about 3 inches is of the same quality of stone, but broken to a 2-inch gauge and mixed with half-inch chippings of the same material. This being again well watered and rolled many times, produces a wonderfully hard and even surface.

The cost of this macadam stone varies according to the size to which it is broken, but would average about $2.70 per ton, delivered in the towns of this district.

The approximate cost of building a main road on which the traffic is very heavy, as is the case in all the pottery towns, is estimated at about $2.44 per superficial or square yard. The estimated annual cost for maintenance and repairs, taking 6 yards as the average width of the roadbed, is $1,296 per mile or 13 cents per superficial yard.

The by or side streets of the towns are made in much the same way as the main roads, with the exception that, on account of the traffic being much less, and so great a depth of foundation being unnecessary, only a 12-inch core of hard material is made, the final layer consisting of broken limestone, about 3 or 4 inches in thickness, rolled and watered as before.

The cost of building these by streets including the cost of paving and curbing with bricks made for the purpose is estimated at $1.80 per superficial yard. There are many of these side streets which have been laid out and built by the property owners, desirous of opening up their property, and the streets not having been turned over to, nor accepted by, the towns, their maintenance devolves upon the property owners.

Where such streets are used by the inhabitants at large, thus making them public streets, and are found to be in bad condition, the property owners are served with a notice to repair or make good the same; should they fail to do so, the town authorities step in and do it themselves, apportioning the cost to the several property owners who are compelled to pay.

The granite used in this district is obtained from the adjoining county of Shropshire and from North Wales; the limestone from Derbyshire.

The wood or Nicholson pavements have been used to a small extent in some of the towns, but do not meet with much favor. It is not solid and durable enough to suit the tastes of a people who glory in their solidity and who, when they build even a house, expect it to stand for generations.

One of the greatest charms of English scenery to the American visitor is the beauty of its hedge-lined, stone-bedded roads. Much of Englands scenery would be nothing without them. Would they not add as greatly to the natural beauties of our own country? The Rev. Dr. Cuyler, of Brooklyn, on the subject of "How to make rural life more attractive," writes as follows:

> Take the single matter of roads, for example. Most country roads are abominable for at least half of every year. They make it very difficult for farmers to drag their produce to the nearest railway or market; they make all social intercourse and travel wretchedly uncomfortable. If country people would open their eyes to this fact and open their hands and pockets to improve their highways, they would find it not only to their pleasure and comfort, but also in the end to their pecuniary profit. Good roads would be one of the first and most indispensable conditions of restoring and reinvigorating the declining country districts.

Nothing can be truer than the above. The fact presents itself strongly to me, as I see daily, the enormous loads of farm produce carted with ease along these country roads by one horse, which at this season of the year (March) in America, would require at least 4 horses, if indeed, it would be possible at all to market the produce.

It is difficult to arrive at any facts in dollars and cents relative to the effect of improved public roads upon the value of land or other economic condition, but the effect of such roads now, and for so long in existence, is seen on every hand and the influence felt in the English mode of life. Englishmen, be they of the gentry or of those in the humbler walks of life, seek their pleasure in and gladly betake themselves to their country homes. The one medium of this pleasure so natural to all men is the solid roadbed over which one can walk, or ride, or drive with equal comfort or pleasure in any day of the year.

WM. BURGESS,
Consul.

UNITED STATES CONSULATE,
Tunstall, March 28, 1891.

IRELAND.

IRISH HIGHWAYS.

REPORT BY CONSULAR AGENT MAGAHAN, OF LURGAN.

CONSTRUCTION AND MAINTENANCE.

In Ireland the construction and maintenance of the public highways throughout suburban and rural districts in each county are regulated by means of the grand-jury presentment system.

Every county is divided into baronies, and in each barony a presentment sessions court is held twice a year, the persons composing the court being the magistrates residing in or having property and jurisdiction in the barony, and a number of the resident rate-payers in the barony, the latter being nominated by the grand jury of the county at the previous county assizes.

Previous to each presentment sessions all applications for the construction of new bridges and roads or the maintenance of existing roads and bridges within the barony are lodged with the secretary of the grand jury, who classifies the applications and attends with them at the court, where they are examined and approved of or rejected.

Advertisements inviting tenders for all such works as have been approved of are then issued and a day for the consideration of the tenders is fixed (this being called the "adjourned road sessions"). The county surveyor, who is the engineer in charge of all the highways, bridges, and other public works in the county, prepares the necessary plans and specifications, and when, after an interval of 3 or 4 weeks, the court—"the adjourned road sessions"—reassembles, all tenders sent in are examined and the several contractors declared, each contractor having to enter into a bond, with sureties, for the due execution of the work.

A list of the contracts thus (provisionally) entered into, giving contractor's name and a brief description of the work, as to length, width, material, and contract price, is then printed for the information of the grand jury at the following assizes, when, if approved of, they are laid before the judge and "fiated" or finally confirmed.

The grant warrant of each assizes (of which I herewith send a copy) contains full particulars as to each contract, together with details as to the amount of tax ("county cess") to be levied on each barony for all purposes connected with roads, bridges, public buildings, salaries of officials, etc.

The grand-jury cess ranges from 8*d* to 20*d* per pound valuation of the lands and buildings in baronial subdivisions of the county. In

this way every barony supports its own roads and bridges, except mail-post roads, which are charged half on the barony and half on the county at large.

The county surveyor is assisted by six or more deputies, in proportion to the area of the county. Appeal on the part of rate-payers against the county surveyor's certificate for payment to any contractor may be made to the grand jury at the assizes, when all grounds of complaint would be inquired into, and, if necessary, to the judge.

EXPENDITURE.

The annual expenditure on the public roads and bridges in the county of Armagh (a small county) is about £22,000 per annum. The expenses are:

One county surveyor	$2,300
Four assistant surveyors, each having his own district	1,600
Secretary to the grand jury	925
County treasurer	1,600
Collector of tax (county cess), probably	5,000

The duties of the secretary of the grand jury and of the county treasurer extend over other departments of the grand-jury system, such as asylums, jails, court-houses, coroners' inquests, etc.

As the county of Armagh is fairly provided with roads, it is not easy to say what is the actual amount of depreciation in the value of land where the lands are inconveniently situated with regard to the roads. It is easy to calculate such case by comparing the actual amount of cartage to and from land per annum, compared with what the cartage would be were the land conveniently situated with respect to a good road.

ROAD MATERIALS.

The materials employed for the construction and maintenance of roads in this country are broken stones and gravel—chiefly depending upon whether the roads are in a stone or a gravel district. For roads subject to heavy traffic broken stone "metaling" is essential, laid on a pavement of stones set on edge closely together, the top interstices being filled with "spawls," so as to provide a firm foundation for the metaling. Round stones, such as are found in coarse gravel, should not be used, as they invariably yield to lateral pressure; therefore "bottoming" should be done with quarry stones or natural bowlders broken to a suitable size, so that the natural rounded surfaces are not in contact with the pavement. The strength of the road crust must be determined by the engineer according to the nature and amount of the traffic to be provided for.

In first-class roads the depth of the foundation pavement should be 12 inches and of the broken stones 8 inches. Second-class roads, foundation pavement 6 to 8 inches, and metaling 6 inches deep.

Stones for metaling should be broken sufficiently small to pass through a gauge ring 2 inches diameter. The full depth of the broken stones should not be put on in one layer, but in two or three layers, each to be fairly consolidated before the succeeding layer is laid on.

MAINTENANCE.

The future maintenance of roads will be greatly increased if strict attention is not paid to the following structural conditions:

(1) Perfect and permanent drainage of the site of the road, such as will provide in future for drainage to a lower level than that of the road foundation. Defective drainage will involve an extravagant expenditure of material for maintenance in wet weather and will require increase of power for the traction of loaded vehicles.

(2) Such fall from the center of the road to the sides, and laterally in the water tables and outside chains as will prevent the water from causing any degree of dampness to the road crust or the substratum on which the foundation rests. With regard to permanent drainage much will depend upon the selection of the line of the road as to lateral gradients, and the question of the drainage of the district.

(3) The quality of the material employed. In many cases road material (broken stone) is found to give way under the traffic in wet weather, producing mud, which increases the cost of scavenging, and renders the employment of such material ineffective, or nearly so. The hardest material within reach should be employed, even at a considerable increase of cost. Stones broken by machinery are not nearly so effective as those broken by hand, as the crushing power applied to break them shatters the natural structure.

THE COST OF ORIGINAL CONSTRUCTION.

First-class.—The cost of earthworks, hedges, and fencing are so very variable in amount that each particular case must be taken by itself, and therefore I can only speak of the cost of bottoming and metaling.

For foundation bottoming, as already specified, having the materials within a distance of 2 miles from the work, per yard superficial, 18 cents; broken stone metaling, 24 cents.

Second-class.—Foundation bottoming, per yard superficial, 10 cents; broken stone metaling, 17 cents.

Extra lead beyond 2 miles would increase the foregoing items of 1*s.* 10*d.* and 1*s.* 1½*d.* per square yard cost to the extent of 10*d.* and 6*d.* respectively for each mile of lead beyond 2 miles.

COST OF MAINTENANCE.

The cost of maintenance is, in practice, very variable, principally dependent upon the degree of perfection with which the road has been

constructed, but largely influenced by the employment of a sufficient number of surfacemen for maintaining the surface in proper condition under skilled supervision. The following particulars are taken from Sir John F. Burgoyne's treatise giving the cost of maintaining the road from Tours to Caen (France), viz:

Year.	Material.	Road labor.	Total.	Year.	Material.	Road labor.	Total.
1832	£872	£195	£1,067	1837	£584	£504	£1,088
1833	708	205	913	1838	445	456	901
1834	745	236	981	1839	412	420	832
1835	671	280	951	1840	271	392	663
1836	684	293	977	1841	163	445	608

The foregoing particulars show that by increasing the skilled labor and diminishing the consumption of material the cost of maintenance is much reduced. This practice, however, has its limits. Care must be taken that the crust of the road shall not be worn down below the thickness as originally constructed.

In the county of Armagh the prices paid per mile per annum for the maintenance of roads of the first-class are as follows:

Highest per mile per annum	$320.00
Lowest per mile per annum	80.00
Average per mile per annum	110.00

In a work on "The maintenance of macadamized roads," by Thomas Codrington, chief engineer (to be had at 446 Broome street, New York), the mean cost of the whole of the macadamized national roads of France for 1876 is given as $165 per mile. In some departments the average is given as low as $75 and $80 per mile. The same authority states that the average cost per mile of turnpike roads in England and Wales was in 1874 $155 and in 1875 $147.

The steam roller for the consolidation of the metaling of newly-coated roads is a recent economic improvement. The road metaling is consolidated at once, a smooth, firm surface is provided, and the broken stones are pressed in their original angular condition. Where the heavy roller is not used the broken stones are subject to great wear by being in a continual state of disturbance, producing mud; the angles are worn round and such compact consolidation as is produced by the roller becomes impossible, and the crust is weak and ill adapted for heavy traffic.

FRED. W. MAGAHAN,
Consular Agent.

UNITED STATES CONSULAR AGENCY,
Lurgan, February, 1891.

BELFAST.

REPORT BY CONSUL RUBY.

There are two classes of streets in Belfast, those maintained by the corporation out of the borough rates or taxes, and those maintained by owners of the property. The latter class are very few in number.

The principal officer in charge of the streets is the city surveyor, who is appointed by the corporation under local act of Parliament. In towns not having a local act he is appointed under the public health act, which is a general one. His immediate duties are those of engineer and surveyor to the corporation and the carrying out of such acts of Parliament as are in force in the city relating to streets and buildings.

The salary and those of his staff are as follows, per annum:

Surveyor	$3,645
Assistant	1,500
General assistants	2,732
Clerks	1,185
Apprentice clerks	219
Building inspector and two assistants	1,540
Outdoor superintendents	2,455

The workmen are employed by the outdoor superintendents, and the wages paid are as follows, per hour:

Bricklayers	$0.16
Stonecutters	.14
Carpenters	.15
Paviors	12 to .16

The gangers have various rates from $6.30 to $6.54 per week.

There are about 150 miles of streets in Belfast, of which about 50 miles are macadamized, ten paved with sets and ninety with sea pebbles.

The cost of repairs in 1890 was about £25,000 to the corporation.

The best paving sets come from Wales, and the present prices are as follows: Four by 4 by 4 inches, $4.36; 4 by 4 by 6 inches, $4.48 on quay in Belfast. Local granite costs about 48 cents per ton less.

The best paving is always executed by the corporation workmen and not by contract, as is usual in the case of most new streets. It is laid on a concrete bed composed of four parts clean broken stones, two parts clean broken brick, two parts clean gravel, and one part best Portland cement. This concrete is made 6, 9, or 12 inches thick, according to the nature of the ground and traffic.

Just before paving the concrete is covered with grout one-half inch thick, composed of six parts screened gravel to one part cement, and the sets are set in this.

The stones are paved close, just touching, and in perfectly straight lines.

The joints are run in with grout of five parts clean gravel to one part cement.

The concreting and paving follow closely. Concrete put in on one day is paved on on the next.

The street is then fenced off from traffic until the whole is properly set. Sometimes in bad weather 2 extra days are given, but as a rule 1 week suffices.

Asphalt is not now used for grouting. It is more costly in case of repairs than cement.

Sets from the Welsh granite company's or Port Neut quarries are always used for the best pavements.

Formerly the size was 3½ inches to 4 inches wide by 7 inches deep, but they have been found rather large to give good foothold. The sets now used are chiefly 4 by 4 by 6 inches deep. This size looks very well, and is very safe for traffic.

Granite sets and local whin stone are used here in small quantities, but they are very costly when the wear is considered, although, being cheaper at first, they tend to keep down the price of the Welsh stones.

For macadamizing whinstone is principally used. It is obtained from the surrounding farms, where it crops up out of the ground. It is broken up by the small farmers during their leisure hours or by the prisoners in the jail and is very cheap. The foundation is made of larger stones than those used on the surface and are firmly rammed in by a hand rammer. It is then coated from 4 to 6 inches deep with broken stones of a finer class. It is then traversed by a heavy steam roller which crushes the stones to a sufficient degree of fineness to make travel easy and agreeable. It is necessary to put on a fresh coat of stones about 2 inches in thickness at periods varying from 1 to 6 months, depending on the amount of travel on the streets.

Wood is not used for paving in this country, as being very expensive.

Where laying out streets in the first instance a plan and specification are lodged with surveyor or corporation by the owner of the property intending to make the street. The surveyor then approves or disapproves of the plan on account of, among other reasons, the lines, levels, width, mode of drainage, or specification proposed, and no street plan can be approved until the surveyor is satisfied.

The owner then makes the street in accordance with the documents lodged, and if he does so the street is adopted and owner is liable to keep it in repairs.

If the street laid out as above be not made by the owner when demanded by the corporation, the corporation makes an order and the owners can be sued for the cost, which is a charge against the property.

The entire cost of making streets is chargeable to the owners, but the corporation may in special cases, if they see fit, bear a share of the cost *i. e.*, a street made for special purpose or of extra width.

SAMUEL G. RUBY,
Consul.

UNITED STATES CONSULATE,
Belfast, *February* 23, 1891.

DUBLIN.

REPORT BY CONSUL REID.

CITY STREETS.

There are three classes of streets in Dublin, each class being constructed with reference to the principal uses to which it is likely to be subjected.

(1) *Stone pavements.*—This class of streets is constructed with special reference to heavy traffic and a great deal of driving. It includes, of course, the principal thoroughfares of the city. The method of construction is substantially as follows: The initial step is, of course, to establish the desired level, which is done by excavating or filling, as the case may be. A foundation for the pavement is then laid, consisting of a bed of concrete 6 inches in thickness, one-eighth part of which is Portland cement and seven-eighths clean gravel and sand. The surface is perfectly and uniformly even and the outline between the curbs is slightly convex, the degree of convexity being 1 inch in 36, so as to throw the water caused by rainfalls into the gutters on either side. Special pains are taken to secure a substantial and durable foundation, as the soil of Dublin as a rule is very bad. The area covered by the newer portion of Dublin, being originally only slightly above the surface of the River Liffey, which divides the city into two nearly equal parts, was very marshy, and now rests largely upon made ground. It may be said in this connection that the street foundations are never disturbed by frosts. The temperature is, of course, very mild. Only a few times during the winter season is it sufficiently severe to freeze a slight crust upon the earth's surface. A covering of 1 inch of fine gravel is then spread over the surface of the concrete for the purpose of accommodating the slight inequalities of the paving blocks.

After the foundation is completed in the manner above described and is sufficiently seasoned the stone blocks or "sets" are laid down in rows, crosswise, in the usual way, and are well rammed into place with a heavy iron-shod mall. A mixture of hot pitch and creosote oil is then poured into the interstices between the sets and the remaining space is filled with fine gravel. The pavement is then complete and ready for use.

The material used for stone pavements in Dublin is taken from the Wicklow quarries and consists of greenstone or trappean rock, a very hard and durable material. In fact the objection is made sometimes that it is too hard, as it becomes dangerously smooth in dry weather, presenting an almost glassy surface.

The size of the blocks or sets is 7 inches long, 6½ inches deep, and 3¼ inches wide. The cost of these sets delivered in Dublin is 24 shillings and 6 pence ($5.96) per ton. One ton of sets suffices to cover an area of 3 to 3½ square yards. The cost of this pavement, including everything, varies from 12 shillings ($2.92) to 14 shillings ($3.40) per

square yard, according to the amount of work done at a time and the facilities for getting rid of the excavated material.

The average durability of a pavement thus constructed and of the materials mentioned is 25 years. Of course some repairs are necessary during this period, but the extent depends largely upon how much the street is broken in laying pipes, repairing and building sewers, etc. The sets are not worn out even after being in constant use during this long period. When replaced they are generally redressed and utilized upon side streets.

The streets in Dublin thus paved are very fine and are frequently commented upon favorably, especially by American visitors. However, they are said to be inferior to the pavements of most English cities. I am informed that the character of the pavements here could be greatly improved by a more perfect dressing of the sets. Under similar conditions the sets used in many English cities cost 29*s.* ($7.06) per ton, the difference in price being made up in the more perfect dressing of the sets. The advantages of more perfect dressing are that a more even and less dangerous surface is secured, and a street over which rapidly moving vehicles make less noise.

(2) *Wood pavements.*—This class of pavement nearly corresponds to what is known as the Nicholson pavement in the United States. It is laid upon some of the strictly commercial streets, where there is only a limited amount of heavy traffic, and opposite churches, hospitals, and other institutions, and in cases where a minimum amount of noise is desirable.

The foundation for this pavement is constructed in exactly the same way and with the same materials as above described in connection with the stone pavement, except that an even more perfect surface is required upon which the wooden blocks or sets are immediately laid. The blocks are laid in rows, crosswise, quite closely together. The spaces between are partially filled, as before, with a mixture of hot pitch and creosote oil. The remaining part of the space is filled with a mixture of one part cement and six parts gravel, to further solidify the pavement and to protect the deposit of pitch and creosote oil from the action of the sun. This makes a very fine, noiseless, and fairly durable pavement, the average life of which is about 10 years.

The materials used for this kind of pavement consist of beech or Archangel deals (pine), the timber first being well seasoned. The size of the blocks is 9 inches long, 5 inches deep, and 3 inches wide. The cost, delivered, is £8 17*s.* 6*d.* ($43.18) per thousand blocks. About 50 blocks are required for each square yard. I should add that before the blocks are placed they are thoroughly creosoted under steam pressure, 10 pounds of creosote being used for each cubic foot of timber.

The cost of a pavement of this description, including construction of foundation, etc., is 14*s.* ($3.40) per square yard.

Macadamized streets.—This class of streets in the city, mainly to be

found in parts outside of the center, over which there is a limited amount of heavy traffic, is constructed in exactly the same way as the country roads, which is described in detail in a subsequent part of this report.

How paid for.—The disbursements occasioned by the construction of all streets within the city limits by the municipal corporation are made from the proceeds of a general tax upon all city property. No part of the cost of the construction of any street specially falls upon abutting property.

Population.—For the convenience of persons who may be interested in the subject-matter of this report, in estimating the probable amount of traffic and the extent to which the public thoroughfares are used, I may add that the population of Dublin, according to the last census (1881), is 249,602.

Vehicles.—Nine out of ten of the vehicles used for carrying goods and conveying people are mounted upon two wheels. As a rule the vehicles, heavy and light, are hauled by one horse only. Heavy loads, however, are hauled in this way, large and powerful horses being used for heavy traffic.

Method of doing the work.—All streets in Dublin are built by day and piece labor, under the immediate supervision of experts employed by the corporation. The wages paid for labor are as follows: Ordinary laborers 14*s.* ($3.40) to 18*s.* ($4.38) per week. Concrete men 22*s.* ($5.35) per week. Rammer men 24*s.* ($5.83) per week. For laying blocks, or sets, a rate of 2½*d.* (5 cents) per square yard is paid.

For the data upon which the foregoing part of this report is based I am indebted to the courtesy of Mr. L. J. Lawless, the assistant engineer of the city of Dublin.

COUNTRY ROADS.

The country roads in Ireland have received and are receiving very considerable attention. However, it is said that they suffer materially from comparisons with the roads in England and Wales, but as compared with the average country road in the United States they seem to approximate closely to perfection, a condition which must not be considered marvelous or even surprising when the antiquity of the country and its settlement are taken into account.

The course described by the country roads in Ireland is most irregular and even tortuous, the apparent purpose being to avoid the points of the compass. Although doubtless not so intended it may be said, in the respect mentioned, they serve to suggest the peculiar individual characteristics as well as the devious historical record of the masses of the people who travel over them. However, as a rule it may be said, at least in partial justification of the arrangement, that the main public thoroughfares in Ireland connect centers of population or interest But the geometrical proposition was unknown or unheeded when the

course of the roads was determined, viz, that a straight line describes the shortest distance between two given points. But for all this I am bound to say that the traveler who is not pressed for time, especially if he is mounted upon other legs than his own, will find greater pleasure in following the ever recurring and graceful curves of the Irish country roads, than in moving in strait lines and turning repeatedly at right angles.

But all this is scarcely even incidental to the immediate work in hand, to which I now give attention.

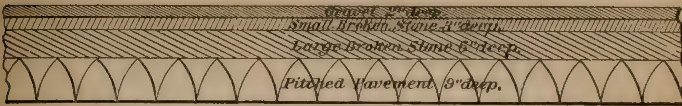
(1) The methods employed in making and maintaining the public roads:

When a new road is constructed a grade is first established generally corresponding (when the roadway is completed) with the contour of the land upon either side. Trenches are sunk on either side to a depth of about 3 feet. The excavated material is used to construct fences on either side. Into the trenches the subsoil of the road is carefully drained by means of narrow cuts, placed herring-bone fashion, filled with field stone to prevent the washing of the surface and through which the water percolates. The original surface of the roadway is then removed to a depth of about 9 inches and an artificial surface of converse section formed and the ground allowed to dry and harden for some time.

The next operation is to make what is called a pitched pavement on this surface, generally of corresponding sections, and about 9 inches in depth, which consists of rubblestone placed on edge across the axis of the roadway. The interstices are filled in with stone chipping, so as to wedge in between the rubblestone forming the pavement. The width of the roadway is never less than 16 feet, and is sometimes much more, according as the local traffic may require. On this foundation is placed broken stone to a depth of 6 inches. These stone are of uniform size, which is determined by causing them to pass through a 3-inch ring. The mass is then rolled three or four times with a roller weighing about 1 ton. Next a coating of smaller broken stone of uniform size, which are passed through a 2-inch ring, is spread upon the surface to a depth of 3 inches. The roller is then applied the same as before. A coating of clean gravel 2 inches in depth is then spread over the surface and the road is complete. The road surface curves slightly from the center towards the sides, the fall being 1 inch in 36. This degree of convexity has been found to be suitable to the requirements of traffic, and is sufficient for proper and thorough surface drainage. When opened for use it is necessary to keep the longitudinal tracks formed by traffic raked in for some time until the mass becomes consolidated.

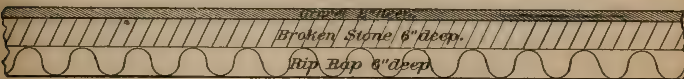
The cost of a road as above described is 2*s.* and 6*d.* (60 cents) per superficial yard, exclusive of the cost of preparing the surface, as this varies according to circumstances.

The cost of maintaining this class of rood varies from 4 to 7*d.* (8 to 14 cents) per square yard per annum.



Section of Road for heavy traffic.

The road I have described above is designed for heavy traffic. The ordinary country road is constructed in a similar way, however, except that the foundation is constructed of field or riprap stone to a depth of about six inches. Upon this is placed a stratum of broken stone, uniform in size, to a depth of 6 inches, and on this again a dressing of clean gravel of 2 inches in depth.



Section of Road for light traffic.

The cost of constructing a road as above described is 2*s.* (48 cents) per square yard. The cost of maintenance is 1 to 3*d.* (2 to 6 cents) per superficial yard per annum.

The broken stone used in road making is of the kind known as greenstone. These are almost entirely broken by hand. For this class of labor the contractors pay 3*s.* and 6*d.* (85 cents) per ton. The men earn at this rate about 2*s.* and 6*d.* (60 cents) per day.

The soil of Ireland is poorly adapted to roadways, the frequent rainfalls making it very spongy. The utmost care in drainage is, for this reason, necessary. However, the roadways suffer but little from the action of frost as it rarely ever penetrates more than two or three inches.

I may add in this connection that nearly all of the bridges in Ireland, large and small, and both in the cities and in the country, are constructed of stone, and are, therefore, very durable. There are numerous bridges of this kind in and about Dublin, over which there is a heavy traffic, that are over a century old, and which are still apparently as substantial as when built.

I find that by consulting reliable statistical authority that there was expended upon roads and bridges in Ireland, during the year 1888, £638,041, a sum equivalent to $3,977,737. It must be borne in mind in this connection that, the country being very old, but comparatively little absolutely new work is required. Hence, for the most part, this sum is expended in repairs and maintenance. The sum named represents about the average annual expenditure, the year 1888 being the leatst for which information under this head is attainable.

It may not be out of place in this connection to state that the total population of Ireland at the present time is estimated to be about 4,700,000, and that the total amount of land-rents for 1889 is £13,969,907.

(2) Details of the system followed:

For the purpose of constructing and maintaining roads and bridges throughout the island, each county is divided into baronies, comprising a certain number of parishes and a certain proportion of town lands. There are several of these baronies contained in every county. The method of proceeding is peculiar, but has been found to be effective and satisfactory. It is substantially as follows: When any new or reconstructed work or repairs are wanted, any two rate or tax payers of a barony make written application to this effect to the secretary of the grand jury for the county comprising the barony, stating the extent of the work wanted and the amount which it is desired to expend. The secretary of the grand jury prepares a schedule of all such applications and submits them to what is known as the presentment sessions of the respective baronies. This is a body made up of the justices of the peace resident of the barony and twelve representative rate or tax-payers who are property-owners in the barony. The rate payers composing in part the board are selected by the grand jury from one hundred of their class whose names are sent in by the tax collector of the barony, after the manner of drawing petit jurors in many of the States of the United States. These men serve upon the board one year only and are replaced from year to year by others of their class in the manner already described. The body thus constituted, holding annual sessions for this purpose, considers the applications presented by the secretary of the grand jury and determines, so far as it is empowered to do so, what applications shall be approved and what shall be rejected, but in no case can it extend or increase the applications. This body is governed to a considerable extent in its conclusions by the recommendations of the district surveyor, who possesses expert knowledge and practical judgment of the matters under consideration. When the work of this body is concluded the applications approved are placed in the hands of the secretary of the grand jury, who has a printed schedule thereof prepared. This schedule is laid before the grand jury of the county, which, for this purpose, meets once a year, in the county of Dublin, and in other counties twice a year, to consider presentments which come to it from the several presentment sessions. The original applications also accompany the presentments. The grand jury has the authority to approve or reject any or all presentments, but it can not alter them. Such of the presentments as are approved are submitted to a judge of the queen's bench, by whom they are fiated if approved by him. I should add here that any cess or tax payer can enter objections to any work at any stage of the proceedings before the barony board, the grand jury, or the judge of the queen's bench. If his objections are valid they will of course be duly considered.

After the presentments are fiated by the judge they are returned to the presentment sessions, which body proceeds to negotiate for contracts for the work. Acting under its authority the secretary of the grand jury advertises for tenders or proposals for each piece of work, according to the terms of the particular presentment. A condition of every proposal is that it must not exceed the amount stipulated by the grand jury for the work. If no proposal is received, or should it exceed the amount previously fixed upon, the district surveyor may be authorized by the presentment sessions to proceed with the work by day labor, but this seldom happens. Every person to whom a contract is awarded is required to furnish two satisfactory sureties. Should he at any time fail to comply with conditions of his contract, the district surveyor can, by giving him 10 days' notice, take charge of the work, the contractor and sureties being held pecuniarily liable for his failure. Nearly all country roads are constructed on the contract system. If the work is limited the contract is usually taken by a local farmer. If the work is extensive it is done by an experienced contractor. All forms of contract are drawn by the surveyor.

I should say here that if from neglect or indifference of local taxpayers applications for needed work are not filed in the usual way, the district surveyor is authorized to act in their stead.

Contracts for repairs or maintenance are made in the same way as for new work, a specimen form being inclosed herewith. These contracts are usually taken for 3 years at so much a running perch, according to the number of cubic yards of material required to be placed and named in the specifications. When the district surveyor directs the work of maintaining a road it is only for 1 year.

All new work and the placing of material for maintenance are required to be done during the months of June, July, and August. All material required for maintenance or repair must be prepared and delivered at stated places on the first of September for use the year following.

The board of works, a general body having jurisdiction over the entire island, can at any time repair roads neglected by the local boards over which her majesty's mails are carried, but the fund thus temporarily drawn upon must ultimately be recouped at the expense of the barony in which the repairs are made.

In the case of a sudden damage to any public road two local justices can direct repairs to the extent of £10 ($48.67) or in a similar emergency they can order repairs to a bridge to the amount of £50 ($243.32.)

How paid for.—The disbursements made in the construction and maintenance of public roads are from a fund derived mostly from a tax levied upon the taxable property in the barony where the work is done. The money is received annually by the grand jury from the baronial collectors. There are also some other sources of revenue derived from probate duties, Government bounty in lieu of rates, etc., partitioned

equally among the different baronies, and from local dog tax. The taxes paid by each barony for road purposes are collected twice a year, in June and December.

When a bridge is constructed involving a heavy outlay the expense is usually borne by the county at large and not by the particular barony in which it is located.

By virtue of a general law under which all roads are constructed none but a main thoroughfare, or one open at both ends, can be improved at the public expense, even though any number of taxpayers might file an application therefor. This is an important safeguard against injudicious expenditure.

As already intimated all financial transactions connected with the building and maintaining of public roads are conducted by the grand jury of each county. All payments are made to contractors quarterly on the certificate of the district surveyor that he is entitled to a certain amount for work performed. In Dublin County the details of this work are performed by a committee of twelve, usually composed of members of the grand jury. In all other counties the grand jury acts for itself. All accounts connected with road building and maintenance are audited once a year by a Government auditor.

(3) General effect of improved highways:

It has been impossible to get any definite statistics or information upon this point. I can only add that the system in vogue has been satisfactory and that the property interests pay the taxes necessary to its support willingly. The opinion generally prevails that the traffic of the country could not be successfully carried on with any less efficient system of highways than that with which the country is provided, and that full value is received for all expenditures made.

For a considerable part of the information necessary to this report, as far as it pertains to country roads, I am indebted to the kindness of R. T. Blackburne, secretary of the grand jury for the county of Dublin, and to Richard A. Gray, surveyor of the county of Dublin.

For the further information of parties who may be interested, I transmit herewith, under separate cover, a copy of the act of 1836, relating to the presentment of public money in Ireland, which covers the ground briefly traversed in the foregoing report. It differs only in some of the details to the act which applies exclusively to the county of Dublin. I also transmit herewith, under same cover, a volume containing presentments passed by the grand jury of the county of Dublin for the year 1890, which explains in detail the method of proceeding.

ALEX. J. REID,
Consul.

UNITED STATES CONSULATE,
Dublin, January 12, 1891.

SOUTH OF IRELAND.

REPORT BY CONSUL PIATT, OF CORK.

There is no radical difference between the city streets and the country highways in the south of Ireland. They are both made of macadamized limestone and are repaired with the same material. The repairing is generally done during wet weather, as the water in the ruts and hollows shows where the surface of the road is uneven and in need of repair. It also tends to keep the broken stones in place by softening the ground and thus allowing them to partly sink into it.

The grand jury has the power to grant permission for the construction of roads. These roads are divided into two classes with regard to the expense for construction and maintenance. That class called "mail roads," from being used by the postal authorities as routes for the mail cars, is built and maintained at the expense of the county at large in which the roads lie. The expense for the other class, called "district roads," is borne by the district in which the roads are situated. However, when a bridge or other work is to be made on a district road which will cost more than the district can afford, the grand jury may levy the expense incurred for the work in question on the rate-payers of the county at large, and then the road will be regarded as one which may be used as a mail route, though the district will otherwise pay for the construction and maintenance.

The expense of keeping roads in good condition depends upon the amount of traffic and upon their situation. The roads about Queenstown, in length about 9 miles, cost for maintenance from £350 to £400 per annum. This is a little above the average, I am told. These are the only details as to expense which I have been able to obtain.

As a general rule new roads enhance the value of the property in their vicinity by affording more direct or better means of communication, and especially by increasing the facilities for the conveyance of farm produce to and from the market towns and railway stations. There are very few instances where the value of property depreciates on account of the privacy of the place being destroyed.

JOHN J. PIATT,
Consul.

UNITED STATES CONSULATE,
Cork, May 15, 1891.

SCOTLAND.

DUNFERMLINE.

REPORT BY COMMERCIAL AGENT REID.

The towns included in this consular district are small, and possess so few of the elements of modern progress that they afford no adequate illustration of any advanced knowledge in the science of street con-

struction which concerns so deeply the prosperity and comfort of the larger centers of population and commerce. There being, therefore, no actual experience here in the matter of city streets which can have any real value in the way of testimony to guide the public inquiry now happily arisen in America, no response to this part of the circular of the Department on "streets and roadways" will be attempted. But on the subject of country roads, which interests all countries claiming civilization, and is rapidly commanding supreme interest in America, I have, with as much care as has seemed possible, collated all the data which road-makers and engineers regard as of practical value.

Adam Smith, who was a citizen of this consular district, and whose great work on the Wealth of Nations has perhaps more than any other cause influenced commercial legislation both in this country and in other lands, used no uncertain language on the value of public roads as one of the primary necessities of civilized life and national prosperity. Splendid roads had been constructed centuries before his time. Their continued existence fifteen hundred years after their construction proved the skill and care of the master minds who planned and built them. But they were constructed in the interest of war. Roads had to be built to move armies for conquest. Roads then became essential to hold the conquered countries. In these commerce had no element or consideration. Indeed it is not difficult to see that public roadways became thus the terror of nations. Even in this ocean-surrounded island, far from imperial Rome, the roads of the Cæsars entered and so terrorized the public mind that it was not until long after the middle of the eighteenth century that turnpikes were first authorized, and were even then inaugurated against the vigorous protests and prejudices of the common people. It seems strange also to know that to the Carthagenians, a people living on the northern coast of "Darkest Africa," must be given the credit of first inaugurating the public road as the necessity of commerce.

THE ROMAN ROAD.

The first inquiry made of a modern educated engineer respecting public roads leads inevitably to the reference to the methods pursued by the engineers of the Roman roads. Although constructed for the purpose of invasion and subjugation they provide still most instructive lessons in methods of construction. Adam Smith's assertion that "the construction of roads is the greatest of all improvements," and the saying of the Abbe Reynal that "wherever we shall find no facility of travel from a city to a town, or from a village to a hamlet, we may pronounce the people to be barbarians," have long, especially in Europe, been accepted by mankind. Roads are the acknowledged civilizers of the world. A road through "Darkest Africa" is fast ending human slavery and introducing light. A good road through Bad Lands would largely settle the question of Indian warfare. It is to methods of con-

struction to which public attention is now chiefly directed. The Roman roads, the via Appia, the via Aurelia, the via Flaminia, the roads to the Rhine and the Danube, and the 4,000 miles of road from the wall of Antoninus, in Great Britain, through Rome to Jerusalem, still reveal lessons of construction worthy of the study of the road builders of the nineteenth century.

The historian Gibbon says of these roads:

They were accurately divided by milestones, and ran in a direct line from one city to another with very little respect for the obstacles of nature or private property. The middle part was raised into a terrace, and consisted of several strata of sand, gravel, and cement, and was paved with large stones, which, near the capital, were of granite.

The following description of the method of construction is given in the French Cyclopædia of 1836.

(1) A cement of chalk and sand 1 pouce in thickness.

(2) On this cement for the first bed large stones 6 pouces thick were placed on one another and compacted by hard mortar.

(3) A second bed, 8 pouces thick, of small round stones, mingled with other broken pieces of building material not so hard, and mixed with a binding cement.

(4) A third bed of 1 foot of cement made of rich earth mixed with chalk.

These beds formed a concrete of from 3 to 3½ feet thick. The whole surface was then spread with a gravel bound in cement mixed with chalk.

These roads were 16 feet wide in the middle, with two side roads 8 feet wide.

They were built either on a level or on a uniform inclination at an easy gradient.

Piles, stone arches, and protecting walls were used whenever the subsoil was not compact.

This road thus constructed has outlived fifteen centuries.

COUNTRY ROADS IN SCOTLAND.

Down to the middle of the eighteenth century the roads of Scotland were of the poorest character. Goods conveyed from place to place, where the distances were not great, were conveyed on horseback. Oatmeal, coals, turf, and even straw and hay were thus conveyed. That was the era of "cadgers." They supplied the country with salt, fish, eggs, and poultry. For longer routes carts were used. Through this very region to go a distance of 38 miles and return required 14 days. It took 14 days, in 1873, to go from here to London. Considering how old is the supposed civilization of this great country, one is surprised to read of one of its chief routes of travel as follows:

I know not how to describe this infernal road. Let me most seriously caution all travelers who may accidentally propose to travel this terrible country to avoid it as they would the devil. I passed 3 carts broken down inside of 18 miles of execrable memory.

This is stated to show that road-making even here is not an ancient science. The first turnpike roads in Scotland were constructed in 1760,

and against the violent resistance and prejudices of the people, who regarded roads as aids to plunder. Except only the remains of the Roman road, the improved roads of this country are of comparatively recent origin, but are now constructed with the utmost care and maintained with scrupulous fidelity.

ROADS IN AND BEYOND FIFE.

The earliest stone roads built through and northward of this district were constructed by Abercromby, an engineer of some note, whose chief formula consisted of the following rules:

(1) Never make a road ascend a single foot unless absolutely unavoidable.

(2) Economy in maintenance depends on an easy gradient.

(3) Hilly roads are full of danger, expensive to maintain, and destructive to horses.

The great Highland roads were constructed with great care and skill and were adapted to the country through which they passed. Although traversing wild mountain ranges, easy gradients were everywhere secured and are unexcelled.

THE MACADAM ROAD AND THE STEAM ROLLER.

Two men of quite recent date were largely instrumental in the introductionof a general system, which is still maintained in its essential features. In 1819 Macadam elaborated his plan of road making and presented it to the British Parliament. Upon its general plan, a vast extension of the macadam road immediately followed.

Perhaps the most important auxiliary to good road making, and by many engineers deemed absolutely essential, was supplied by M. Polonceau in 1834, by the introduction of the steam roller. Excepting a very decided variance of opinion on the comparative advantages of soft and hard foundations, the macadam road is the generally accepted road of the country for country roads, and has stood the test of long and varied experience.

RESISTANCE TO TRACTION.

A few years ago road-making science expressed itself as follows as to traction:

(1) Resistance is directly proportional to the load and inversely to the diameter of the wheel.

(2) Upon a paved road the resistance is independent of the width of the tire when it exceeds 3 to 4 inches.

(3) At a walking pace the resistance is the same to carriages with or without springs, but increases on macadam roads with the velocity, and less as the road is smooth and the carriage less rigid.

(4) On soft roads or freshly graveled roads the resistance to traction is independent of velocity.

(5) The destruction of roads increases with reduced wheel diameter and in carriages without springs.

GRADIENTS.

The steepest gradient, according to one authority, that can be properly allowed on roads with a broken-stone covering is about 1 in 20, as this, from experience, according to the same authority, is found to be about the angle of repose upon roads of this character in the state in which they are usually kept. Engineers of eminence insist, however, and with apparent justice, on a much lower grade. Sir John Macneil asserts, as a fact not generally known, that "if a road has no greater inclinations than 1 in 40 there is 20 per cent. less cost for maintenance than where the inclination of the road is 1 to 20. The additional cost is due not only to the greater injury by the action of horses' feet on the steeper gradient, but also to the greater *fatigue* of the road by the more frequent necessity for sledging or braking the wheels in descent."

The same authority adds: "Experience teaches that on broken-stone roads in perfect condition the resistance to traction is of the gross weight or 45 pounds per ton, for which the angle of repose is 50. The traction force required is just double that which is required on a level."

FOUNDATIONS.

Mr. Macadam maintained that a soft and yielding foundation for a road is better than one that is firm and unyielding. He argued that a road on a soft foundation being more yielding and elastic the materials of which the covering of the road was formed would be less likely to be crushed and worn away by the passage of a heavy traffic than on a hard solid.

This theory of road foundation is still held by some, but rejected by the majority. Experience seems to have proved that there is no more general cause of bad roads than soft foundations. A firm, solid, and dry substratum is necessary for the road materials to rest upon. The outer surface of the road, it is urged, should be regarded merely as a covering to protect the actual working road beneath, which should be sufficiently firm and substantial to support the whole of the traffic to be carried over it. The lower, or subroad, properly provided for, and the upper covering renewed from time to time, should last forever. The following are directions now generally in force.

Where the expenditure is limited and the traffic moderate every care should be taken to make the roadbed as solid as possible. If the ground is wet, deep ditches should be cut on each side, and cross underdrains should be formed.

Where the ground is very soft a layer of faggots or brushwood from 4 to 6 inches thick should be laid over the surface of the ground to receive the road materials. Where the ground has been recently deposited the surface should be rolled or beaten to render as solid as possible.

CONCRETE FOUNDATIONS.

Macadam's theory of the advantage of soft foundations, especially when made to apply to roads likely to bear a heavy traffic seem now very generally discarded. In roads subject to heavy travel concrete is insisted on and has shown proof of its value. From a leading authority the following quotation is made :

The concrete used is similar to that used on the old Roman roads. It is a mixture of gravel and lime. The lime is ground to a fine powder, water is added and every particle of the lime slaked and saturated.

The bed of concrete having been spread to the depth of 6 inches the surface is then covered over with 6 inches of good hard gravel or broken stone, and this depth is laid on in two courses of 3 inches at a time, the first course to be laid on a few hours after the concrete has been placed on the road. The covering of gravel is laid before the concrete has become hard, to admit of more perfect junction between the two beds. The lower stones thus united become a fixed matrix and not easily dislodged. On some roads where the obstacles to sound foundation were great and apparently insuperable, the use of cement or concrete foundation has been eminently successful.

One of the principal advantages of using concrete is that a good and solid road can be made with material such as gravel, which is usually readily found, and which on any other mode of application would be unsuited for the purpose. The gravel should be clean and mixed with sand and then mixed with one part of lime to six of gravel. On adding water the whole should be quickly and thoroughly mixed up, thrown into place, and the first layer of broken stone or screened gravel be placed just as the concrete is about to set.

THE MACADAM THEORY.

In 1816 James L. Macadam put in practice his system of roadmaking, which is eminently worthy of restatement in this inquiry. His principle was "to put broken stone upon a road which shall unite by its own angles so as to form a solid, hard surface. When this material is thus laid upon the road it must remain in the situation in which it is placed without ever being moved again, whereas gravel, before it becomes useful, must move its situation and be in constant motion." The principle was "to substitute small angular stones such as resulted from the breakage of larger stones, for rounded stones, so as to form a sort of mosaic or interlocking system."

This system, which experience has thoroughly tested and approved; the provision of solid foundations, which seems to be proved of the first importance; and the use of the steam roller in securing thorough impact, are the three vital elements of the successful modern road.

On these three principles of road building the following roads have been extended within a comparatively short period:

	Length of road.	Area.	Population.
	Miles.	*Sq. miles.*	
Great Britain	160, 000	122, 519	30, 621, 431
France	100, 048	210, 460	38, 192, 064
Prussia	55, 818	139, 675	23, 970, 641
Spain	10, 886	198, 061	15, 673, 481

CONVEXITY OF ROADS.

Macadam gave the following testimony before a committee of the House of Commons, and which is practically the judgment of the most experienced road builders:

"I consider that a road should be as flat as possible with regard to the water flowing off, because a carriage ought always to stand upright I have generally made roads 3 inches higher in the center than at the sides, and on this slope the water will easily escape. When the road is made flat people will not follow the middle of it as they do when extremely convex. More water will stand on a very convex road than on a flat, because all carriages seek an upright position in the center, and the wear there will, of course, be greater. The most useful inclination is in the direction of a road's length, and engineers give preference to a moderately inclined road over one rigidly level. To secure an equal distribution of service every part of a road should be equally hard and good to prevent unequal wear."

HIGHWAYS IN THE DUNFERMLINE DISTRICT.

I am indebted for much of what follows to personal interviews with and documents furnished to me by John Maclennan, esq., for some years president of the association of road surveyors for Scotland.

(1) *Road routes.*—Other things being equal a road route should be chosen having the freest exposure to sun and wind.

(2) *Gradients.*—Gradients should not exceed 1 in 40. Easy gradients are preferable to dead levels, securing drier and more compact roads.

(3) *Foundations.*—All roads should have foundations to be determined by the character of the soil on which they are laid. On roads of moderate travel, the soil light and the natural or unstoned road, well compacted, unbroken and of easy gradient, the necessity for special foundations is absent, and, according to Macadam, unnecessary. Wherever, however, the surface is broken either to elevate or depress, the ground should be well rolled or tamped. Where the soil is soft and yielding or an active traffic is likely, the foundations become important. Stones laid on their flattest side and compacted with broken metal, ashes, or the like, require to be carefully laid. Even cement, in which gravel forms a useful constituent, becomes essential if the nature of the soil is yielding and the traffic heavy. New macadam roads are now generally made with a foundation from 6 to 12 inches of stone shivers, slag, brick rubbish, or other inferior character, on which 6 inches of hard metal is laid.

(4) *Drains.*—In forming road foundations the proper provision of drains is important. These, whether by side ditches or by lateral or transverse carefully constructed drains, are essential to a good and economical maintenance of a road under the best conditions. Existing conditions will determine their character and mode of structure.

(5) *Character of stone.*—The stones employed on Scotch roads are of the hardest and toughest attainable. In these the granites are by far the most serviceable, and that because of their unstratified character. Granite, named so from its coarse granular structure, has for its prevailing elements a crystalline compound of three simple minerals—feldspar, silica or quartz, and mica—silica varying in proportion from 65 to 80 per cent. and usually in an amorphous condition, cementing the feldspar and mica. Granite is capable of absorbing 10 pounds of water per cubic yard=1.450 of its weight. Perhaps the most valuable stone for macadamizing roads is the Welch stone, greywacké of Penmaenaur, in Wales, which, while of the same weight as granite, is much harder and is so highly esteemed that enormous quantities are sent by ship and rail to the large towns in the north of England, Scotland, and Ireland. This shows the value of hardness in the metal for public roads. The following table may be of interest:

Stone.	Specific gravity.	Crushing resistance per square inch.	Weight of water absorbed in 48 hours.
Graywacke	2.75	7.54	1 part in 1641.
Granite, Scotch	2.67	5.74	1 part in 490.
Sandstone, English	2.41	4.38	1 part in 47.

Of Scotch granites Guernsey is the most durable. The most important quality in stone for roadmaking is toughness. Mere hardness without toughness is of no use, as such stone becomes rapidly reduced to powder by the action of wheels. The sandstones and the limestones are to be avoided because of their affinity for water, by which in frosty weather, which has been preceded by wet, they are split up into powder and the solidity of the road is destroyed.

(6) *Breaking the stone.*—The quality of stone proper for the metaling of the road is scarcely more important than its preparation. It should be reduced to angular fragments of such a size that each piece will pass freely through a ring of 2½ inches in diameter in every direction. Broken stone is superior to gravel, and, wherever obtainable, should always be employed. Pebbles, when cleaned, never bind until they become ground and worn down and are incapable of supporting the pressure of heavy wheels. If gravel be employed, experience seems to indicate that it is best to leave some binding material to adhere in order to secure firmness and cohesion.

There has been introduced into the service of the roads in this district a stone-breaking machine with good effect and economical results. The comparative cost of breaking stone by machine and hand labor is as 1*s.* per ton for the former against 2*s.* 3*d.* per ton for hand labor. In a trial of the two systems 3,325 cubic yards of stone broken by machine cost £169 18*s.* 7*d.* while the same quantity broken by hand cost £398 4*s.*

(7) *Metaling the road.*—The foundation of the road having been care-

fully provided, and which, as has been stated, can be done either, for roads of moderate travel, by thoroughly drying and solidifying the soil by tamping or rolling, or, as recommended by able engineers, for roads of larger travel, of using soft stones or cinders, the stones being "carefully set by hand, broad end down, in the form of a close, neat pavement," there shall then be placed 6 inches of broken stone to such width as may be desired, but so laid that the entire width shall form a convex line or segment of a flat ellipsis the arch of which shall not exceed 6 inches in 30 feet. This shape not only assists the water to pass from the center toward the sides, but contributes to the drying of the road by allowing the action of the sun and air to produce a great degree of evaporation. The use of the steam roller in at once compacting and smoothing the road, it is believed, is becoming more and more acceptable, and producing, both in construction and repairs, very useful results.

(8) *Road repair.*—The following quotation from a report of Government Surveyor Maclennan is pertinent and complete:

The chief end of road repair is a smooth, hard, and slightly elastic surface. To secure this the metal should be of uniform size and quality. Small 2-inch whinstone metal is, in my opinion, the best. Large metal, although ever so well blinded and rolled, will in a very short time present an uneven surface, not having the same capacity for forming into the concrete as when smaller. Hard and soft stones should not be mixed. The soft stones are quickly ground into mud, while the hard protrudes, rendering the surface rough and uneven. When the surface is very sorely worn I apply a small sprinkling of clay to give a bed for the new material. Work of this kind requires experience and care. I believe in giving good convexity to the road. Water should run off quickly to avoid great waste and damage. After distributing metal a stone roller of 1 ton weight is used to secure a fair surface. In the matter of "blinding" I am convinced that where the subsoil is retentive and the surrounding ground wet, spongy, and of a clay nature, the less blinding the better for the road. A smooth and beautiful surface may be quickly secured, but the deterioration is equally rapid. The men appointed for surface repair have much to do with the road's success and should be selected with great care.

(9) *Foot roads.*—The provision of foot-paths is important, but seems not generally provided for. When made the refuse of the road and gravel are used.

(10) *Depots.*—On all important roads depots of stone occupying a small space, more or less frequently, along the margin of the road are provided, where the stone is broken, generally by hand, and kept ready for use.

(11) *Effect on property valuation.*—To this inquiry the prompt reply was: "Roads are the life and necessity and hope of all Scottish industries, and their value increases rather than diminishes with railroad extension. Property would without them be comparatively valueless."

(12) *Cost of maintenance.*—The cost of maintaining the public roads in this district averages £18 per mile, and is provided for by a tax averaging 6*d.* on the pound of rentals, equal to about 2 per cent. They are under the supervision of a surveyor appointed for each district, a

master of works for each town of importance, all other labor being employed for brief periods or for special work. Wages of "surface men," 18*s.* per week ($4.50).

(13) *Cost of construction.*—The cost of construction of an ordinary public road eighteen feet wide would be, in Scotland, about £300 per mile. Any increase in cost would depend on increased width of road, distance of quarry, and method of foundation. As in many other things, the cheaper the construction the more costly the maintenance.

Such is my response to the Department circular of November 8, 1890, based on as complete information as is available to me; yet it is sent with hesitation as being to some extent, perhaps, crude and incomplete.

JAMES D. REID,
Commercial Agent.

U. S. COMMERCIAL AGENCY,
Dunfermline, January 1, 1891.

GLASGOW.

*REPORT BY CONSUL BROWN.**

The streets of Glasgow are the best paved of any city with which I am acquainted; the roads of Scotland are certainly very superior, and as far as I have been able to observe, better, as a whole, than those of the other countries of the United Kingdom.

SCOTCH HIGHWAYS.

Road system.—The country road system of Scotland may be regarded as a growth to meet the wants of the public and as a result of experience in carefully providing for, by studying the best methods, the public needs, its present state of excellence, approaching perfection, not having always existed, though for scores of years Scotland, even in the Highlands, has been famous for her good roads.

A hundred years ago the population in some districts was already becoming quite dense, and the need of good roads and how to build them naturally commanded the attention of the public and officials. Sixty years ago and before the country was interwoven with a network of railways and when traffic and travel were already considerable on the great stage routes to London, as well as to other leading centers, good roads were more than a luxury; they became a necessity and required to be perfected and kept up at any cost. What wonder, then, that the roads now are in excellent condition everywhere.

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* In connection with this report I am indebted to Dr. W. H. Hill for valuable documents, and to John L. Imrie, esq., a farmer residing near Glasgow, for much practical information.

L. W. B.

Comparatively few new roads are now being built, because not needed, but the old ones are constantly being improved by cutting down high grades, filling in the low places, renewing the top dressing, etc.

This cutting down and leveling of the roads, when done by contract, costs 20 to 28 cents per cubic yard, which cost includes removal and dumping into the low places if the distance is not too great.

A considerable force of men is kept constantly employed improving and repairing the roads, the counties or shires, for road purposes, being divided into divisions, these being subdivided into districts, the latter embracing from 15 to 30 or more miles of road. The districts are in turn subdivided into sections, upon which squads of men, from three to six in number, according to the needs of the road, are kept constantly at work the year round.

A heavy steam-roller, 10 to 15 tons, plays an important part in road repairing as well as road making, and though of comparatively recent introduction is now regarded as essential, the larger or 15-ton roller being considered the better and more economical. One roller, with its complement of men, does its part of the work upon several of the above-described sections. Cost per diem of using these rollers will be considered hereafter.

CONSTRUCTING NEW ROADS.

The first step in constructing a new road is to lay tile on each side of the roadbed, the tile as a rule being laid 3 feet below the surface and ranging in size from 3 inches to 6 or more inches, the cost of laying, exclusive of the tile, being for 3-inch tile (reducing to United States currency) 3 cents, 6-inch tile 4 cents, and 9-inch about 6 cents per yard. The latter size is seldom used.

In preparing the roadbed the upper or surface soil to the depth of 8 to 12 inches is first removed; upon this exposed surface or bed a foundation is laid, called "bottoming," which consists of large cobble or broken stone, carefully set, the stone foundation thus formed being 6 to 10 inches deep, according to size of stone used, the cost in a great measure depending upon the accessibility of stone. Upon this rough roadbed or foundation is scattered fine broken stone called metal, and fine enough to pass through a 2-inch ring, to the depth of 4 inches, in addition to filling up interstices of the bed-stone. This metal costs from 72 cents to $1.68 per cubic yard, according to quality, the latter price being paid for a choice quality almost equal to granite in hardness and durability.

The whole is made a compact mass by throwing on gravel, sand, or the refuse of the broken stone heaps, and if these are not attainable in sufficient quantity, sometimes soil nearest approaching sand is used; this is wet down, a large quantity of water being used, and rolled many times over, until the whole becomes almost as firm as a stone pavement sufficiently smooth for a delightful carriage road and nearly perfection for carting purposes.

This roadbed is built from 16 to 30 feet wide, according to volume of travel expected, and in the case of the narrower width is about 7 inches higher in the middle than on the sides and in the broader width about 1 foot higher in the middle. A sufficient depression is made on either side to carry off the surface water.

This, I am sure, will be accepted as pretty nearly a model country road, but it is not all of the road for in addition there is built on one or both sides of the road a footpath from 2½ to 4 feet wide, this being a feature of all the newer roads and many of the old ones. This footpath or sidewalk is made by simply throwing up the soil a few inches higher than the side of the road and covering it with coal ashes or cinders, gravel, or like substance, and after being worn for a little time is almost equal in dryness to the city sidewalk and is quite as comfortable to walk upon.

Roads thus built are durable in character, yet do require repair, and to keep them in a high state of repair and excellence, as heretofore stated, a considerable force of men is constantly employed.

REPAIRING OF ROADS.

Keeping the roads in proper repair consists in keeping them clean, removing dirt, droppings, and rubbish of all kinds, and in filling up depressions with fresh metal, rolling down, etc. In this connection it may be well to state that the roller is employed upon all parts of the road, even when new metal is not spread, it being considered very useful in keeping the road solid and preventing depressions, which would require filling up. The cost of these repairs is very considerable, as will be seen from the following:

I take at random from the tables of estimated cost before me—the sixth district of the county of Lanark. The district comprises 16¼ miles of road upon which there is a heavy traffic. The estimated cost of management and maintenance for the year 1891 is as follows:

	£	s.	d.
Metal (fine broken stone)	1,627	5	9
Surface work	589	9	6
Tools	15	7	4
Removing mud, etc	194	6	0
Footpaths and borders	85	16	6
Drains, gratings, etc	349	7	9
Repairs on walls, fences, etc	105	13	2
Improvement on Carmunnock road	665	0	0
Cost of working steam road roller, including driver's wages, fuel, carting water, etc	239	14	11
Sundries	18	3	9
Total	3,890	4	8

Equal to $18,906.52 United States currency.

From this total there should be deducted the cost of the improvement of Carmunnock road, which leaves a balance of £3,225 4*s.* 8*d.* or, in round numbers, $15,675, nearly $965 per mile of road.

Twelve men are employed upon the roads of this district. Of these twelve men two receive $6.07 each per week, one $4.86, two $4.62 each, six $4.38 each, and one $4.14 per week.

The following table shows the cost per diem of the roller wages, viz:

1 engine driver	$1.04
1 assistant	68
1 watchman	64
1 man blinding metal	72
2 men for water, at 72 cents each	1.44
2 men for sweeping, at 72 cents each	1.44
Foreman or surfaceman of the district, $1 (say half his time)	50
Cartage:	
2 water carts, at $2.16 each	4.32
1 cart for blinding, $2.16 (but as this would, without the roller, be required, say to one-third the extent)	1.44
Materials:	
Coal	30
Oil, packing, etc	16
Brooms	16

Interest and depreciation at 15 per cent. per annum on cost of roller, $2,433, and for repairs and insurance, $364.50. Deduct from last item 52 Sundays and 42 days for frost, in all 94 days, the charge in respect to above is per working day $1.30.

To the expense of management the following items should be charged, being approximate cost of management for a county:

Salary of secretary and treasurer, £600; surveyor, £400; collectors commission, 2½ per cent.; carriage hire and expenses of inspectors, say, £100; printing, stationery, advertising, postage, etc. Total, say, £1,500, nearly $7,500.

The official machinery made use of, construction of committees, of county council, for road management, quite unlike our own, and as I think rather cumbersome, is not considered essential to this report and is therefore omitted.

It may be an interesting item to note the length of time some of the men are employed. In the district of which I have given a detailed report, one man, Andrew Hamilton, has been continuously in service 50 years. He is now 70 years old and receives $6.06 per week. Another man has worked 26 years, one 16 years, one 14, and the other eight from 7 years down to 6 months.

TAXATION FOR ROAD PURPOSES.

The assessment is made upon the rental value of real estate, and at the rate of 6*d.* to 8*d.* per pound sterling, paid in part by the owner and part by the occupier, usually one-half by each. Take the 8*d.* per pound rate, allowing £2 ($9.73) as the minimum rental value of farming land, and the valuation of our farm lands would surely average that much or more, we have $25.60 annual tax upon a farm of 80 acres, for repair

and maintenance, after first cost is paid. When our people are ready to pay such a price, we can surely have first-class macadamized roads, equal to those of Scotland.

As to the question of enhanced value of real estate on account of improved roads, I can only conjecture. I am informed by intelligent farmers that the rental value of farm lands is at least 5 per cent. higher where the roads are such as I have been describing than where the roads are but ordinary or poor. The land for the most part is owned by landlords and seldom changes hands; but it is safe to assume that the value is increased from 20 to 25 per cent. by good roads.

STREETS OF GLASGOW.

Pavements in use in Glasgow are of three kinds, viz, granite or whinstone, macadam, and wood. The latter, however, has not been extensively used, hardly sufficient to be worth mentioning, is considered a failure, and when worn out will doubtless be replaced by one of the others. I think there is less than a mile of wood paving in the city, hence its construction is not described.

A. B. McDonald, esq., city engineer, to whom I am indebted for information in relation to Glasgow street paving and other courtesies as well, writes me that:

The whole of the streets within the city of Glasgow with the exception of the old turnpike and Statute Harbor roads have in the first place been formed and paved by the proprietors at their own expense, principally with flat topped rough whinstones called rubble whinstone causeway. Turnpike roads were originally formed and maintained out of funds raised by the levy of tolls, the description of paving used being what is known as macadam. These streets when taken over by the city authorities to be maintained out of city rates have been gradually remade and repaved to suit the altered requirements in regard to traffic, gradient, and nature of occupancy of abutting buildings.

TRAFFIC.

Mr. McDonald further says:

In determining the most suitable material for paving, heavy and light traffic is calculated on "actual teaming," not the weight of any load which may be expected to pass over it, as all the roads paved with square dressed sets are expected to bear, with safety, the passage of loads of from 60 to 80 tons carried on four-wheel bogies.

The heavy traffic is principally on the main thoroughfares and the streets in the portion of the city occupied by warehouses, stores, and business premises. These as a rule are paved with square dressed granite, exception being made in such portions of streets as front law courts or infirmaries, where wood blocks or macadam are laid for the prevention of noise.

The light traffic is of two classes, one a combination of goods and carriage traffic and the other solely carriage traffic. The first embraces the streets partly occupied for residential and business purposes, in which the paving material is whinstone, the latter, for residential purposes alone, being paved partly with whinstone and partly with macadam.

PAVING MATERIAL.

The granite used for paving sets in Glasgow is a close-grained porphyry from the Scotch quarries, situated on Loch Flyne and Loch Etive, and has been proved to be

the most durable material for paving purposes to be found in the country. Under heavy traffic it has been found to last for 30 years without requiring to be lifted, and when dressed and relaid, is expected to last for another 25 years, before being broken up for macadam, or laid in streets subject to light traffic. The granite metal largely used in macadamized roads is from the same quarries.

The granite used for water channels, not being subject to the same wear as the street, is brought from the Dalbeattie and Ardshiel quarries; it is larger in grain and softer in quality, but of a lasting nature.

The whinstone, principally from quarries around the city, is heavy and close-grained, and while not so lasting as granite, lasts as long under the lighter traffic to which it is subjected in the minor thoroughfares where whin paving is adopted. It is not so slippery as granite, and on this account is used in several of the heavy traffic streets where the gradient is pretty heavy. Whin metal from the same quarries is also largely used for macadamizing purposes.

The securing of a sure foothold for horses is an important factor in determining the sizes of sets for paving purposes, and on this account no paving blocks now being used exceed in breadth 4½ inches or in length more than 9 inches. In some cases they are now laid as narrow as 3 inches; but with such a breadth there is the disadvantage that when they become worn and require to be lifted they will not redress to advantage, while a stone 4 to 4½ inches broad can be depended on to redress and relay well. At street junctions where a foothold is required in all directions the sets are square instead of oblong, not exceeding 4½ inches on the top. The depth of the stone may vary from 7 to 5 inches, and in the case of junctions where the form of the stone does not admit of much depth they may be from 6 to 4 inches deep. The same remark as to after facility for redressing and economy holds good in regard to depth.

Water channels are of dressed stone from 12 to 14 inches broad, 6 to 7 inches deep, and of an average length of 3 feet. It should be borne in mind that these sizes of sets, etc., are those now used. On many of the streets, the pavements having been laid many years ago, the sizes are larger.

In all cases, whether as a paved or macadamized road, it is considered of the utmost importance to secure a properly consolidated foundation. For this purpose the roadway is excavated to the required depth and to the levels and curves of the intended surface, all soft places being rammed solid, or, when necessary, such as over drains and pipes recently laid, cut 6 inches deeper and filled up with concrete. As I have watched the work going on no part of the work has so much impressed me as the thoroughness with which the roadbed is prepared.

The specifications herewith sent, furnished me by Engineer McDonald, fully describe the manner of carrying on the various works connected with the paving of the streets, while the schedule attached gives the prices paid under the present contract.

Attention is called to the use of both cement and asphalt for paving purposes, the former being generally preferred for use in bottoming, but for grouting paving sets the latter, because it sets in a few hours and allows the more rapid use of the street. For this reason in some cases it is necessary to use asphalt for both bottoming and grouting purposes.

MACADAMIZED STREETS.

For macadamized streets the same care is observed in excavating to the required depth, which in this city varies from 18 to 20 inches below the intended finished surface. In forming a first-class macadamized

road Mr. McDonald says "a coating of engine ashes or some similar substance 2 inches deep should be laid over the excavated surface wherever the soil is of a non-porous nature; where of sand or gravel or other absorbent material the ashes may be dispensed with." Heretofore this has not always been done. Upon this is laid a bottoming of rough stones (sand stones if possible) 9 inches deep and not more than 4 inches broad on the head when laid, all carefully hand set and so lapping in the joints as to present the appearance, when completed, of a dry stone wall laid flat, the open joints being filled with the small chippings and the surface even, no stone projecting beyond another. On this is laid a coating of from 4 to 6 inches of 2½-inch metal, which, after being blended with sand and watered, is gone over with a 15-ton steam road roller to be consolidated; a second coating of 2-inch metal mixed with a proportion of small ground whin or granite, according to the nature of the material with which the road is to be finished, is then put on and again watered and rolled.

As the road consolidates under the rolling 12-inch metal is laid on and rolled in until the necessary finished level has been attained. A proportion of road scrapings is used where it can be got along with the ground chips for the purpose of binding the metal.

It is found that granite metal makes a more perfect road and does not require so much cleansing as the whin.

It is considered desirable in all macadamized roads that the sides should be paved with square dressed sets with properly laid channel stones.

The cost of forming a macadamized roadway as described, including rolling complete, varies from 3*s.* 6*d.* to 4*s.* (84 cents to 96 cents) per square yard.

Mr. McDonald says: "No street is considered as permanently paved" until it is causewayed with square dressed sets. The money required for this work is borrowed under parliamentary powers, the interest upon same as well as the annual amount required as sinking fund being chargeable against the rate-payers. The rate of interest is partly 3¼ and 3½ per cent.; the sinking fund upon the amount of debt to be repaid, as at the passing of the roads and bridges act, 1878, is 2½ per cent., and upon all sums borrowed since passing of said act 5 per cent.

The total amount expended in permanently paving the streets in Glasgow from May 15, 1856, till May 31, 1890, has been £538,714 15*s.* 4*d.*

The net cost of repairing the streets in Glasgow during the year ending 31st May, 1890, was £18,585 7*s.* 7*d.*

The number of miles of streets maintained by the road authority in Glasgow is 142, this being exclusive of suburbs, which would nearly double the amount.

L. W. Brown,
Consul.

United States Consulate,
Glasgow, March 2, 1891

SPECIFICATION FOR EXECUTING THE PAVING WORK REQUIRED BY THE MAGISTRATES AND COUNCIL OF GLASGOW (POLICE), INCLUDING THE SUPPLYING OF THE NEW PAVING SETS, CHANNEL STONES OR WHEELERS, AND ALL THE MATERIALS AND WORKMANSHIP, FOR THE PERIOD OF THREE, FIVE, OR SEVEN YEARS.

The paving operations to be commenced within 6 weeks from date of acceptance of offer, and the streets finished and open for traffic within such period as may be from time to time fixed by the statute labor committee.

Paving stones.—Each set must be properly dressed, squared, and level on the tops and beds, the sides and ends to be parallel and square. The sets must be of the sizes as marked on the schedule, truly gauged, and approved of by the master of works. No bulges or hollows will be allowed on any pretext whatever.

Channel stones or wheelers.—To be neatly axed, perfectly straight and square on the upper surface, the sides and ends perfectly straight, parallel and square off the surface, and the bed parpend with the same. The stones to be 10, 12, 13, 14, and 15 inches broad, and 5, 6, and 7 inches deep. The average length to be 3 feet 6 inches, and no stone to be less than 2 feet 6 inches long.

Crossings.—Paving sets for crossings to be axed on the top, but in every other way to be the same as those already described, and of the sizes as marked in the schedule.

(NOTE.—These are never required. The ordinary sets above specified are found to do sufficiently well.)

Removal of present paving stones or macadamizing.—The present paving stones, which remain the property of the magistrates and council, to be carted away in sections by the contractor to ground or streets as directed by the statute labor committee. The square sets intended to be relaid to be redressed to the sizes as specified in the schedule of rates, and to the entire satisfaction of the master of works, the redressing to be done at such place as the master of works may direct, the contractor being bound to cart the stones to the street in which they are to be used after they have been redressed.

Excavation.—After the present paving sets have been removed, the street to be excavated to the depth of 12½, 13½, 14½, or 15½ inches (to suit the different depths of stones) below the intended finished level; the necessary transverse curve or rise from the sides to the center being given to the bed. Where the streets are to be paved with redressed stones, the street to be excavated to the depth of the sets in the same proportion as above stated.

Where the streets are macadamized, the contractor to remove the macadamized material and excavate the streets to the depths before stated. The macadamizing may be used for bottoming, so far as found suitable for that purpose, but it must be thoroughly screened in order to remove any sand or mud.

Bottoming.—After the ground has been carefully prepared to the required sections, a bed of the best whinstone metal, 6 inches in depth, broken to pass through a 2-inch ring, shall then be laid over the whole surface of the roadway, be thoroughly grouted with a mixture of the best British bitumen and pitch oil, and thoroughly beaten with a rammer while being grouted, the finished surface to be perfectly smooth. The whinstone metal must be thoroughly dry before being grouted with bitumen.

In the event of the board deciding that a concrete bottoming be substituted in place of the foregoing, it shall be composed of 1 measure of the best Portland cement to 1 measure of clean sharp river sand and 3 measures of Whinstone Metal, broken to pass through a 2-inch ring, all properly mixed previous to being laid on the roadway. The surface of the compound, when placed in its position, must be perfectly smooth and to the entire satisfaction of the master of works. The contractor to state whose Portland cement is to be used.

Causewaying.—The whole prepared surface to be paved with square dressed sets, assorted according to size, both as to width and depth, before being laid, and set on a bed of sharp clean river sand, in no place less than 1½ inches in depth. The sets to be laid (close up, hard to hard on the sides and ends, and properly banded) in

straight and regular courses across the street between the channel stones, and to levels shown on the sections, proper molds, carefully set every shift, being used if required for guiding the workmen, the whole to be afterwards well grouted with Portland cement and bitumen, and beaten down with a beater not less than —— pounds in weight, and regrouted, as also blinded with gravel, one-fourth inch in depth. If considered necessary by the master of works, the contractor is bound to put on blinding a second time. The master of works to give instructions as to size of sets to be used in every street.

Grouting.—Cement grouting to be composed of one measure of best Portland cement to two measures of clean sharp river sand, all properly mixed.

For bitumen bottoming and grouting, the bitumen shall be manufactured from pure coal-tar pitch from gas works, and the oil shall be of 1.000 to 1.10 specific gravity. Sufficient oil shall be used to produce a plastic grout. The contractor shall also be careful to see that the grout is boiling hot when used. The contractor to intimate to the master of works the name of the parties from whom the bitumen is obtained.

When the master of works considers it necessary that chips of the same class of material as the paving set should be used in the filling in of the joints, the chips must first be passed through a half-inch riddle, then be thoroughly kiln dried, and afterwards passed over a riddle of one-quarter-inch mesh to remove all sand and dust, and laid in the joints in two layers. Previous to the chips being put between the joints, bitumen shall be run in to the depth of 1 inch, the first layer of chips shall then be put in, and thoroughly grouted with the bitumen, the second layer of chips to fill the joints level with the surface, and to be thoroughly grouted as directed. One ton of chips shall not do more than 240 square yards.

Labor, carriage, etc.—The contractor to find all labor, tools, and plant, carriage, sand, whinstone metal, gravel, bitumen, cement, paving sets, and all other materials required for the execution and completion of the contract.

Watching and lighting.—The contractor to be bound to provide a sufficient number of watchmen and lights, and become responsible for any damage that may be done to life or property in consequence of his operations, or from deficiency of watchmen or lights.

Maintenance.—The contractor to be bound to maintain the work for 6 months after its completion, and to deliver the same over to the board in a proper state of repair at the end of that period.

Materials and workmanship.—The materials to be of the best quality, from any quarry or quarries that may be approved of by the committee. The workmanship to be of the best description, and to the entire satisfaction of the master of works, or of any person appointed by him to superintend the work, who shall have power to exclude or reject any defective material or workmanship; and, in the event of the contractor delaying or refusing to replace the materials or renew the work, the committee shall have power to do so at his expense.

The contractor to lodge specimens (carriage free) of all the different sizes of stones specified, at the master of works' office, 6 days before offers are lodged. These stones will become the property of the magistrates and council, and will be held as samples of the dressing of the stones to be supplied under the contract.

Payment.—Payment to be made to the extent of 90 per pent. on the value of work done monthly, the work to be measured when finished, and the balance to be paid when the master of works shall have certified that the work has been done and maintained as before specified, and delivered over in terms of contract. Should any repairs be necessary at the end of the period fixed on for maintenance, the same shall be made good by the contractor, and, in the event of his failing to do so, the committee shall have power to order the same to be done; the expense so incurred to be chargeable against contractor, and to be deducted from any balance which may be due to the contractor at the time. One-half of measurer's fee to be paid by the contractor.

Alterations.—The committee reserve power to make whatever alterations, additions, or deductions they may consider necessary; the price of such alterations, additions, or deductions to be regulated by the rates of prices contained in the contractor's tender.

Completion.—The contractor to proceed with the different portions of the works as directed; and should it appear to the master of works that at any particular time the work is not being proceeded with in such a manner as to secure its completion within the time specified, the committee shall have power to take the work out of the contractor's hands, and complete the same at the contractor's expense.

Power of dismissal.—Should the master of works, or inspector appointed by him, be dissatisfied with the method of conducting the work, or of the workmanship thereof, as conducted by any foreman or workman employed by the contractor or contractors, they shall have the power to order his or their instant dismissal.

Disputes, etc.—In the event of any difference of opinion or dispute arising between the master of works, or his inspector, and the contractor, the same shall be referred to ———, whose decision shall be final and binding on both parties.

Contract.—The contractor or contractors will require to enter into a deed of contract, based on the foregoing specification, and the accepted tender, containing the above and the usual conditions, and to pay one-half the expenses thereof.

Tenders to be lodged with Mr. Lang, clerk to the magistrates and council (police), 74 Hutchinson street, on or before the ———, indorsed "Tender for paving work." No tender will be received after 12 o'clock of said date.

The magistrates and council do not bind themselves to accept the lowest, or any tender.

OFFICE OF PUBLIC WORKS,
74 *Hutchinson street, Glasgow,* ———.

TENDER.

———, ———, 18—.

To the MAGISTRATES AND COUNCIL OF GLASGOW (POLICE):

GENTLEMEN: —— do hereby offer and agree to execute the work with connected the paving of streets in the different districts of the city, as pointed out by the master of works, for the periods of three, five, or seven years from the acceptance of this offer, with new granite, whin, or old redressed stones, all in conformity with the specification thereof, and at the following schedule rates.

Your obedient servant,

——— ———

Schedule of rates for executing the paving work required by the magistrates and council of Glasgow (police), including the supplying of the new paving sets, channel stones, or wheelers, and all the materials and workmanship, for the period of ——— years.

BOTTOMING WHERE REQUIRED.

	s. d.
Whinstone bottoming, 6 inches deep (including cutting), grouted with bitumen as described, including all materials and workmanship (removal of present causeway or macadam included in all paving work) .... per sq. yard..	3 0
Concrete bottoming (including cutting), 6 inches deep, as described, including all materials and workmanship (removal of present causeway or macadam included in all paving work) .... per sq. yard..	2 10

No.	Sizes.		Granite sets, as described in specification, per square yard, grouted.			Whin sets, as described in specification, per square yard, grouted.			Redressing and relaying old granite and whin sets (belonging to the magistrates and council), as described in specification, per square yard, grouted.		
			With bitumen.		With cement only.	With bitumen.		With cement only.	With bitumen.		With cement only.
	Breadth.	Depth.	With chips in joints.	With bitumin only.		With chips in joints.	With bitumen only.		With chips in joints.	With bitumen only.	
	Inches.	*Inches.*	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1	3	5	(*)	(*)	....	(*)	(*)	....	2 3	2 4	1 9
2	3	6	11 6	11 7	10 11	8 8	8 9	8 1	2 4	2 5	1 9
3	3	7	12 6	12 7	12 0	9 1	9 2	8 7	2 5	2 6	1 11
4	3	8	(*)	(*)	....	(*)	(*)	....	2 6	2 7	2 0
5	3½	5	(*)	(*)	....	(*)	(*)	....	2 3	2 4	1 9
6	3½	6	11 6	11 7	10 11	8 8	8 9	8 1	2 4	2 5	1 9
7	3½	7	12 6	12 7	12 0	9 1	9 2	8 7	2 5	2 6	1 11
8	3½	8	(*)	(*)	....	(*)	(*)	....	2 6	2 7	2 0
9	3 to 4	5	10 2	10 3	9 7	7 9	7 10	7 2	2 4	2 5	1 9
10	3 to 4	6	10 10	10 11	10 3	8 2	8 3	7 7	2 4	2 5	1 10
11	4 inch cubes....		9 4	9 5	8 10	7 4	7 5	6 10	2 4	2 5	1 11
12	Any size		....	....	....	....	....	....	†1 9	†1 10	†1 2

* Not used at present. † Without redressing.

CHANNEL STONES OR WHEELERS, AS DESCRIBED IN SPECIFICATION.

No.		Grouted with bitumen, 5 to 7 inches deep.		Grouted with cement, 5 to 7 inches deep.	
		Granite.	Whin.	Granite.	Whin.
		s. d.	s. d.	s. d.	s. d.
1	10 inches broad, per lineal foot	1 5½	1 3½	1 4½	1 2½
2	12 inches broad, per lineal foot...............	1 7½	1 5½	1 6½	1 4½
3	13 inches broad, per lineal foot...............	1 7½	1 7½	1 6½	1 6½
4	14 inches broad, per lineal foot...............	1 9½	1 9½	1 8½	1 8½
5	15 inches broad, per lineal foot...............	1 11½	1 11½	1 10½	1 10½

Extra excavation over depths specified, 2 shillings per cubic yard.
New granite referred to in above schedule of rates to be from ——— ———.
New whin referred to in above schedule of rates to be from ——— ———.
(Name of party tendering to be signed in full) ——— ———.
(Address) ——— ———.

DISTRICT OF LEITH AND EDINBURGH.

REPORT BY CONSUL WALLACE BRUCE.

Edinburgh and the adjoining seaport, Leith, have two distinct and separate corporations, but, in appearance, they are one large city, bound together and interlaced by their connecting lines of busy com-

munication which extend over a wide area. The population according to latest official estimate is, respectively, Edinburgh, 275,436, and Leith, 80,736; total, 356,172.

The streets and roads within the municipal boundary of Edinburgh are under the superintendence of the town council of said city, and those within the Leith municipality are superintended by the corporation of Leith.

CITY STREETS AND ROADWAYS.

The following statement sets forth the materials used and the methods employed in making the streets and roadways of Edinburgh and Leith, the cost of building and maintenance of same, and other informa tion relative thereto:

(1.) HEAVY TRAFFIC STREETS.

Granite and whinstone paving.—The ground forming the carriageway in Edinburgh streets is excavated to the depth of about 15 inches under the level of the proposed finished surface of the carriageway. A foundation of cement concrete 6 inches thick is then laid down and beat solid, and adjusted to the requisite levels. The concrete is usually composed of small broken stones and cement in the proportions of five measures stones, one measure cement, and two measures fine sand or gravel, the stones being bedded or built on a cushion of sand 1 inch deep, which is laid on the concrete. In Leith the concrete is sometimes formed of broken whinstone, gravel, or ballast and lime, in the proportions of one measure of slacked lime to one measure of broken stone and one of gravel; then over the concrete a layer of sand about 1½ to 2 inches thick is laid down, and upon this sand the paving stones or sets are laid. The paving stones or sets are squared blocks of granite or whinstone, 8 to 14 inches long, 7 inches deep, and generally 4 inches thick. When the paving stones have been laid to the proper lines or levels, and as the work proceeds, the whole surface is grouted, that is, the joints are filled up with lime mortar, composed of one measure of slacked lime to two parts of fine gravel. The whole of the sets are then beaten down about a half inch or three-quarters of an inch with heavy beaters and the surface of the paving adjusted. The curvature of such carriageway is three quarters of an inch or thereby on 3 feet from channels to center.

The cost of streets paved in this way is, for granite, $2.43 to $2.92, and for whinstone, $1.70 to 1.94 per superficial square yard. Granite paving sets cost at the quayside in Leith, including all dues, $5.60 to $6.07 per ton of 2,240 pounds, and 18 cents to 24 cents per ton will lay them on the ground for the pavers. Whinstone sets delivered at works cost $3.16 per ton.

Wood paving.—In Princess street, Edinburgh, a leading thoroughfare of that city, the carriage traffic is very great, and one section or side of

it to the extent of 200 yards is laid with Scotch grown beechwood blocks in place of the granite or whinstone already described, and, so far as experience yet goes, it has given satisfaction during the 2 years it has been in use. But about 16 years ago other streets of Edinburgh were laid with pine or Baltic redwood blocks, and such paving has not proved satisfactory. Some of the wood in those streets was removed after 8 or 10 years' wear, and the streets were repaved with stone. Wood paving is very favorably accepted by shopkeepers and residents, where it is laid on account of the comparative noiselessness of the traffic upon it, but it is not so durable and therefore not so economical as stone. Wood also leads to much more expense in its maintenance. The wood blocks used are of similar dimensions as the stone, namely, about 9 inches long, 7 inches deep, and 3 to 4 inches thick. The manner of laying the wood in Edinburgh streets is the same as that of laying the stone pavement.

The paving of two streets in Leith has been made of pitch pine and redwood. The blocks used were 9 inches long, 6 inches deep, and 3 inches thick, laid upon a foundation of concrete, composed of one part of Portland cement to four parts of ballast or gravel 6 inches in thickness. The wood blocks forming the pavement were placed about a quarter of an inch apart from each other and the interstices filled with liquid bitumen. These cost for pitch pine 9*s.* 6*d.* ($2.31) and for redwood 8*s.* 6*d.* ($2.07) per superficial square yard.

Val de Travers paving.—In one case a street in Leith was paved with Val de Travers compressed rock asphalt 2½ inches thick, laid upon a foundation of Portland cement concrete 9 inches thick. This paving has stood all kinds of traffic for 18 years, and is, even now, in fair condition, and has proved to be a very great sanitary improvement in the locality. The cost of such paving was 15*s.* ($3.65) per superficial square yard, including all excavations, concrete, and paving. It was maintained by the contractors for 3 years after construction free of charge. For 15 years the cost for maintenance was about 2½*d.* (5 cents) per superficial square yard over the whole area paved. This system is, however, better for level streets than for any gradient, as it is too smooth for horses to get sufficiently secure footing.

(2.) MEDIUM TRAFFIC STREETS.

If the foundation or substratum of the carriageway be of a suitable character, such as firm sand or gravel, the concrete is dispensed with, in which case the cost of paving will be reduced by about 48 cents to 54 cents per superficial square yard, or the cost of the concrete and excavations.

(3.) LIGHT TRAFFIC STREETS.

Common whinstone paving.—The mode followed in paving streets wherein there is light traffic in Edinburgh, is as follows (that in more private parts of the city is generally causeway of a commoner class

of whinstone blocks, with less dressing upon them than on the blocks where the traffic is heavy): The ground having been carefully prepared—but without any concrete foundation—such causeway is laid upon it, the joints or interstices in some cases being filled with bitumen or Portland cement grout. The cost of such work is about 97 cents to $1.21 per superficial square yard. Other light traffic or private streets and roads are "macadamized."

Macadamized roads.—Macadamization, or the process of covering roads with broken stone, came into use in Scotland early in the present century, having been invented by John Loudon Macadam, a Scottish surveyor, and his system was so designated after his name. His system was made known in two works, entitled, respectively, A Practical Essay on the Scientific Repair and Preservation of Public Roads and Remarks on the Present State of Road Making. According to Macadam's invention excellent roads were formed by placing in a suitably prepared road layers of broken granite or other hard stone, which became hardened into a solid mass by the traffic passing over them. For this invention he was, in the year 1827, granted a sum of £10,000 ($48,665) by the British Government.

Throughout Edinburgh the process adopted for macadamizing streets or roads having light traffic is, in laying the foundation, to adjust, equalize, and thoroughly beat down and otherwise prepare the bottom ground to the same curvature as the intended finished surface, the rise being from channels or sides to the center of the carriage way of 1 inch on 3 feet or thereby. Then broken whinstone or "road metal," as it is termed, is laid down from 8 to 10 inches deep, the material being blinded—that is, filled up and rolled—with road scrapings. Ordinary scrapings of a macadamized road make the best blind, being of a cementing or binding nature, and this is finished and left smooth for traffic by the application of horse rollers.

The city of Edinburgh possesses a 20-ton steam roller which has been used in preparing macadamized roadways for traffic, but it is found unsuitable. Horse-rollers, varying from 2 to 3 tons, each drawn by two horses, are found more suitable for the purpose.

In the suburban streets and roadways of Edinburgh where "road metal" is used the cost of macadamizing is from 60 cents to 73 cents per superficial square yard.

The first cost of building or constructing and paving those private streets and roadways is assessed upon the proprietors on both sides of the street or way, in proportion to the lineal frontage.

The ordinary public streets of Edinburgh extend 108 miles; private streets and suburban roadways about 20 miles.

Throughout Leith the method of constructing streets or roads for light traffic on Macadam's principle is as follows: The carriageway is excavated to the depth of about 10 inches under the intended surface thereof, and when this has been done a stratum or layer of broken

stones about the size of 4-inch cubes is laid down. Upon this is placed a layer 4 inches deep of broken whinstone, or "metal," as it is usually termed, about 2-inch cubes. Upon this metal is laid a layer of finer metal about the size of a walnut and 2 inches in thickness, and the whole well blended with crushed gravel—a material which is obtained from the stone-breaking machines when making metal. The whole is then rolled and consolidated with a heavy roller. This costs in the first construction about 73 cents per superficial square yard. The principal part of constructing streets is, in the first instance, done by contract. The rate of 73 cents per square yard superficial includes the cost of the water channels and curbing at the sides of roads. The expense of engineering, preparation of plans, superintending, or measuring work, is, however, not in any case included in the rates given, but if such were allowed for, a sum equal to 5 per cent. at least on the cost would require to be added.

(4) MAINTENANCE.

Granite-paved streets.—The cost of maintaining granite-paved streets for the first 10 years after construction is very small, indeed almost nil, and, from that time onwards to a period from 20 to 25 years after construction, the annual cost per yard for maintenance will not exceed 4 cents, and at the end of that time the paving, as a rule, requires renewal, and the material taken from it may be used in paving quiet streets.

Whinstone-paved streets.—The cost of maintaining whinstone-paved streets for the first 5 years after construction is almost nil, but from that time onwards till about 15 years after construction the maintenance may be taken at 4 cents per yard per annum, and when repaved the old material may be broken up and used for repairs of roads, the making of concrete, etc.

Macadamized roads.—With respect to macadamized roads—being those constructed for lighter traffic—the cost of maintenance may be taken at 6 cents per superficial yard per annum, but this rate will no doubt be varied according to circumstances, such as the state of the weather and the amount of traffic.

There are not any of the roads in or immediately around Leith where the traffic may be said to be really light in the sense that there are no vehicles passing over them carrying goods or general merchandise of a heavy character, but, on the contrary, they are all liable to have any kind of traffic, at times, carried over them.

(5) ASSESSMENT OF FIRST COST.

All the streets and roads within the boundary of the city of Edinburgh, both carriageways and footways, are maintained by the magistrates and council out of the municipal assessment of usually 5*d.* (10 cents) per pound ($4.8665) on the rental of the city.

In constructing public streets of any large extent the cost is gener-

ally defrayed by borrowing money on the security of the municipal rates or assessment and repaying the loans in 20 years. In this way the assessment is not so greatly increased and felt. The assessment for maintaining the roads and streets of the town of Leith at present is *4d.* (8 cents) per pound ($4.8665) on the valued rental, exclusive of the value of the Leith docks, which, by statute, are exempted from assessment for roads and streets.

The cost of the first construction of roads or streets upon lands laid out by the proprietors or owners of same for the erection of dwelling houses or other buildings thereon is paid by such proprietors or owners, or by their tenants or lessees who have acquired such lands, and, if the work of construction be to the satisfaction of the corporation, the maintenance of such roads or streets is thereafter assumed by the corporation, and the expense is paid out of the general assessment for that purpose.

The cost of land upon which the streets or roads above referred to have been formed has in no instance been taken into account in the prices stated for their construction and maintenance.

Subjoined is a statement kindly supplied to me by the city road surveyor, showing the amounts estimated under the several headings for wages, materials, etc., expended on the Edinburgh streets and roads for the current year (from May 15, 1890, to May 15, 1891).

Wages:	
Breaking stones	$1,581.61
Labor on macadamized roads	10,462.98
Labor on causewayed streets	19,320.00
Forming and repairing cesspools	2,043.93
Works on depots	2,919.90
Foot pavements and footpaths	851.64
Public safety	97.33
Total wages	37,277.39
Materials, cartage, etc.:	
Material, macadamized roads	12,166.25
Cartage, macadamized roads	4,379.85
Stone, causewayed streets	5,839.80
Sand and gravel, causewayed streets	4,379.85
Cartage, causewayed streets	6,509.78
Cesspools and channels	2,919.90
Depots, repairs, and furnishings	486.65
Implements and repairs	2.189.92
Public streets, contract work	29,199.00
Improvements	486.65
Private streets	9,733.00
Foot pavements, contract work	26.765,75
Footpaths, gravel and cartage	973.30
Granolithic footpaths, public street	13,626.20
Public safety	973.30
Total materials, etc	120,689.20
Grand total	157,966.59

COUNTRY ROADS OR HIGHWAYS.

The materials used and the methods employed in making and maintaining the country roads within this consular district and other information pertaining to same are as follows:

THE MIDLOTHIAN ROADS.

Edinburghshire, or, as otherwise named, the county of Midlothian, occupies an area of 358 square miles or 229,120 acres. This area, in the management of its roads, is divided into four districts, namely, the Edinburgh suburban, the Lasswade, the Calder, and the Galawater district, each having its board of road trustees, under whose care the roads in the respective districts are maintained and who control the expenditure required upon them.

In this county there have been two methods used in making and maintaining its roads or highways, viz, those of Telford and of Macadam. Briefly stated, the Telford system consisted of a bottoming of large wedge shaped stones set on end, sharp edge uppermost, with a covering of broken "metal" (stones) on the top. That of Macadam consists of a bed of "metal" broken to a uniform size from top to bottom The latter system has been adopted throughout the county of Edinburgh for many years past, and on account of its giving a smoother surface to the road is considered preferable to the Telford system. It is preferred also as avoiding the risk of the large bottoming stones used in the Telford system working up to the top, which, it is said, happens in nearly all roads having pitched or paved foundations. The first cost of macadamizing a road is usually from 60 cents to 70 cents per superficial square yard.

The main lines of roadway throughout the county of Edinburgh are from 25 to 30 feet wide from fence to fence, the greater width being required for roads of much traffic or near the city; and under the "roads and bridges act" of the year 1878 it is ordained that no erection shall be built more than 7 feet high within 25 feet of the center of the roadway. The old parish roads in the county, however, are often not more than 15 feet wide, but these are frequently being made wider where greater traffic or other circumstances require the improvement. The roadways are maintained with whinstone procured in the neighborhood, broken to a uniform size of 2½ inches, and applied according to the amount of traffic.

In the suburban district of the county of Edinburgh the cost of maintenance of macadamized roads, including the footpaths, varies with the traffic upon them. For instance the cost per mile of roadways leading from quarries is as high as $1,313.95 per mile, while the average of other main lines leading from the city into the country is about $369.85 per mile.

The mode of constructing roads known in Great Britain as the Tel-

ford system above mentioned was invented by Thomas Telford, a celebrated Scottish civil engineer, who accomplished much of the improvement in highway communication which was made throughout this island in the beginning of the present century.

In connection with the above reference the following extract from one of Telford's specifications of the manner of constructing a road 30 feet in width by his method may be deemed of value:

Upon the level bed prepared for the road materials a bottom course or layer of stones is to be set by hand in form of a close, firm pavement. The stones set in the middle of the road are to be 7 inches in depth; at 9 feet from the center 5 inches; and at 15 feet 3 inches. They are to be set on their broadest edges lengthwise across the road, and the breadth of the upper edge is not to exceed 4 inches in any case. All the irregularities of the upper part of the said pavement are to be broken off by the hammer, and all the interslices to be filled with stone chips firmly wedged or packed by hand with a light hammer, so that when the whole pavement is finished there shall be a convexity of 4 inches in the breadth of 15 feet from the center.

The middle 18 feet of pavement is to be coated with hard stones to the depth of 6 inches. Four of these 6 inches to be first put on and worked in by carriages and horses, care being taken to rake in the ruts until the surface becomes firm and consolidated, after which the remaining 2 inches are to be put on.

The whole of this stone is to be broken into pieces as nearly cubical as possible, so that the largest piece in its longest dimensions may pass through a ring of 2½ inches inside diameter. The paved spaces on each side of the 18 middle feet are to be coated with broken stones or well-cleaned strong gravel up to the footpath or other boundary of the road, so as to make the whole convexity of the road 6 inches from the center to the sides of it, and the whole of the materials are to be covered with a binding of 1½ inches in depth of good gravel free from clay or earth.

When stones are very hard they never make a very smooth surface. Limestone will make a much smoother surface than whinstone and other harder stones, but they should not for this reason be preferred to harder stones, for these will wear longest, carriages will run lighter over them, and the expense for scraping and repairing will be less. All the soft kinds of stones make heavy roads in wet weather, and in dry weather there will be more friction upon roads made with them, because there will be more dust on their surface.

The breadth of the road which has been described in the foregoing specification of 30 feet is recommended as fully sufficient for any road forming the approach to a very populous city. The confining of a road to this breadth contributes very much to preserve the whole surface of it from side to side in a good state, and to diminish expense. For, when a road is of greater breadth, the scraping and repairing of the excess beyond 30 feet costs annually a considerable sum.

With respect to the convexity of a road, it should be so arranged that it should be slight in the middle. In giving a convexity of 6 inches to a road of 30 feet in breadth, the convexity at 4 feet from the center should be half an inch, at 9 feet, 2 inches, and at 15 feet, 6 inches. This will give the form of a flat ellipse.

Whenever the natural soil is clay, or retentive of water, the pavement acts as an underdrain to carry off any water that may pass through the surface of the road. The component stones of the pavement having broader bases to stand upon than those that are broken small, are not so liable to be pressed into the earth below, particularly where the soil is soft.

Notwithstanding the foregoing apparently plausible reasons in favor of Mr. Telford's system of constructing roads, it has been discontinued in the county of Midlothian for a considerable time, and that of Macadam is preferred. It might be well also to add that in a country of severe

frosts the Telford roadway might be more readily upheaved, from the nature of its construction, than that of Macadam.

The process of macadamizing the county roads is very similar to the process under that name described in the previous section of this report with reference to city or suburban streets and roads.

A brief summary of those accounts of the Midlothian county roads, estimated expenditure for maintenance for year ending May 15, 1891, exhibits the following results:

Suburban district of Edinburgh.

Material, estimated expenditure: Ninety-one roads, extending 108 miles 6 furlongs 9 yards, required 18,537 cubic yards of metal (broken whinstone), which cost from $1.25 to $1.86 per cubic yard, amounting to....		$25,920.88
Material and labor, total estimated expenditure....		43,406.70
Deduct amount to be contributed by the city of Edinburgh....		9,733.00
		33,673.70
Suburban district rental, £234,250 ($1,139,977.62) assessment thereon at 6½*d.* (13 cents) per £1 ($4.8665) yields	$30,874.39	
Allowance from British Government, say	3,406.55	
		34,280.94
Leaving for miscellaneous expenses....		607.24

Lasswade district.

Material, estimated expenditure: Eighty-one roads, extending 142 miles 6 furlongs 10 yards, required 7,360 cubic yards of metal, which cost from 99 cents to $2.08 per cubic yard, amounting to....		12,192.60
Material and labor total estimated expenditure		23,746.67
Lasswade district rental, £188,027 ($915,033.40), assessment thereon at 6*d.* (12 cents) per £1 ($4.8665) yields....	$22,875.83	
Expected allowance from Government....	1,849.27	
		24,725.10
Leaving for miscellaneous expenses		978.43

Calder district.

Material, estimated expenditure: Eighty-three roads, extending 156 miles 5 furlongs 186 yards, required 7,705 cubic yards of metal, which cost from 97 cents to $1.50 per cubic yard, amounting to....		10,429.21
Material and labor, total estimated expenditure		19 105.53
Calder district rental, £164,698 ($801,502.81), assessment thereon at 5½*d.* (11 cents) per £1 ($4.8665) yields....	$18,367.77	
Probable allowance from Government	1,459.95	
		19,827.72
Leaving for miscellaneous expenses....		722.19

Gala Water district.

Material, estimated expenditure: Seventy-three roads, extending 150 miles 3 furlongs 131 yards, required metal which cost from \$1.01 to \$1.74 per cubic yard, amounting to		\$5,951.56
Material and labor, total estimated expenditure		10,825.33
Gala Water district rental, £83,402 (\$405,866.14), assessment thereon at 6*d.* (12 cents) per £1 (4.8665) yields	\$10,146.89	
Grant from Government, say	875.97	
		11,022.86
Leaving for miscellaneous expenses		197.53

Galashiels district.

In further illustration of the second section of my report, I beg to submit the following account of the country roads and highways in the neighborhood of Galashiels and other southern portions of this consular district.

The borough of Galashiels has a population of 19,000. The municipality of Galashiels have the management of their streets and roads under a local act, in which it is provided that streets or roads which are to be built upon on both sides must be 40 feet in width between building and building, and those built upon one side only, 25 feet.

Original construction of roads.—The municipal authorities, in terms of the statute, fix the levels of all streets about to be formed with a view to uniformity. The road or street is thereupon formed, and, on the assumption that the total width is to be 40 feet, the road or highway is made 24 feet in width. The bed is excavated to the depth of 6 inches, and raised in the center to the extent of about 4 inches. "Metal" composed of clean hard whinstone and broken so as to pass through a 2½-inch ring, is laid upon the bed 6 inches deep, and finished in a neat and uniform way. Sometimes the metal is blinded with earth so as to facilitate its consolidation. The cost, including the provision of the metal, may be stated at 60 cents per superficial square yard.

Maintenance of roads.—Once every 2 or 3 years a layer of "metal" 3 inches thick is put upon roads where traffic is somewhat heavy, which is usually all that is required for their maintenance. This entails a cost of about 16 cents per superficial yard. A road upon which the traffic is ordinarily light can have 100 yards of its length maintained at a cost of \$2.43.

Curbs and sewers.—On each side of the road a curb and sewer are formed for the purpose of conveying rain and other water from the streets. These occupy a space of about 2 feet in width. The curb is composed of a block of clean hard whinstone or granite, measuring in inches 16 by 10 by 5. The sewer is composed of three blocks of the same material. Each block is 8 inches wide and 6 inches deep. The curbstone is placed on its edge next to the footpath, and the sewer stone next to it is laid with a slope of about 3 inches, its upper edge being about 1 inch below the top of the curbstone, while the other two stones

are laid with a slope to the center of the sewer, and in a line with the proposed contour of the road. The various stones are set upon a bed of clean sharp sand or ashes 4 inches deep.

The cost of the original construction may be stated at curbstone 32 cents and sewer 39 cents per lineal foot.

Maintenance of curbs and sewers.—These are maintained by the renewal at the same cost of the parts in disrepair. They usually require no repair for from 10 to 15 years after their construction.

Original construction of footpath.—The footpaths are constructed on both sides of the street and are 6 feet in width and have a fall toward the curb and sewer of three-eighths of an inch to the foot.

There are many methods and different kinds of material that may be employed in the construction of footpaths, but two of these obtain in and around Galashiels; these are:

(1) *Formed with concrete.*—This is most decidedly the preferable method, although the more expensive. The earth is excavated to the depth of 12 inches below the upper edge of the curbstone. Eight and a half inches of this space is filled with rough gravel or clean stones broken to go through a 3-inch ring, solidly beaten down and leveled; then follows a 2-inch layer of concrete composed of four parts of clean washed gravel to one part of best Portland cement, well beaten down; and before it sets the top layer of 1 inch thick is laid. This top layer of concrete is composed of two parts crushed granite to one part best Portland cement, and is finished off straight and smooth. Thin slips of wood are inserted across the footpath every 6 to 8 feet so as to prevent the blocks of concrete being joined. The cost is about $1.09 per superficial yard.

(2) *Causeway or method known as hornizing.*—The bed is excavated as before and the bottom filled with some approved material; then follows a layer 4 inches deep of clean sharp sand or hard ashes, upon which the stones immediately after referred to are set. These stones are clean, hard water or river stones and are placed upon their edges and pounded down with heavy beaters so as to produce a level surface. These stones measure from 1½ to 2 inches thick, from 4 to 5 inches deep, and from 5 to 8 inches long. The cost may be stated at 48 cents per superficial yard. This method is probably the more durable, as in many cases it lasts for 25 years.

Maintenance of footpaths.—This depends upon the traffic, but in ordinary circumstances no repairs would be required for from 15 to 25 years. If any portion of a footpath requires repair it can be done by renewing the only part in question, and, in the case of concrete, the cost would be about 79 cents per superficial yard, as only the top layer would require removal. In the case of the other method it would cost the same as the original work.

WALLACE BRUCE,
Consul.

UNITED STATES CONSULATE FOR LEITH,
Edinburgh, January 31, 1891.

CONTINENT OF AMERICA.

BRITISH NORTH AMERICA.

THE IMPORTANCE OF HIGHWAYS.

REPORT BY CONSUL TANNER, OF PICTOU, NOVA SCOTIA.

It is my opinion that when all the inquiries of this circular have been compiled it will be found that no known system of road or street construction can be compared with that of the Romans.

These roads, many of which were constructed 300 years before Christ, are good roads to this day. Roads may come and roads may go, but the Roman road endures forever. The prime object of the Roman highways was to facilitate the movements of troops and army transportation and the quick concentration of troops at a given point. The soldier, his helmet and shield, spear, and accouterments have passed away; the republic itself, the result of their prowess and valor, is a thing of the past, a dream; but the highways remain a lasting monument to their skill and civilization, and if modern times have improved on the methods then practiced, but little if any improvement at all can be traced.

Enough can be traced from ancient history to enable us to form a tolerably correct idea of the methods of road and street building adopted by the Romans. The first object sought was shortness between two given points, the commencement and the terminus. A straight line was drawn from point to point and the road was ordered built on this line regardless of valleys, hills, mountains, or other natural obstructions, and that which engineers pronounced impractical, indeed impossible, was accomplished because it was imperative.

This being determined, two ditches on either side of the road to mark the width were dug, and the soil between removed until a solid foundation was reached. This soil was replaced by more solid material well packed and made thoroughly compact, and every precaution taken that the body of the road should be hard and strong.

This strength was made perfect by four layers of material, the lower layer consisting of large flat stones, if convenient; if not, other stones were used, and these were laid in mortar. The next layer was of small stones or coarse concrete; the third of finer concrete, on which was laid stones of several angles joined nicely and solidly together, which was the fourth layer. These four layers constituted a thickness of from 3 to sometimes 7 feet. On a hard, rocky foundation the two under layers were dispensed with.

This pavement extended nearly the entire width of the roadway, which varied from 13 feet to sometimes more than 20 feet in width, according to its importance.

This account is taken principally from a French work on the ruins of Pompeii in my possession.

These are the leading features in Roman road and street paving construction, for one, in my opinion, varies little from the other. A highway should be made as much for pedestrians as for horses and wagons, and I shall treat this subject from this standpoint in my reply to this circular.

REQUISITES OF A GOOD HIGHWAY.

It is shortness from point to point, a good smooth surface, capable of sustaining great weight without becoming muddy, and over which man and beast can pass with comfort and ease. I have given my opinion of how such a roadway may be secured; any further details may be found with minuteness in any first-class encyclopedia, stated with much more clearness than I can state them.

I had the honor several years ago to report upon the subject of highways to the Department (Consular Report No. 24, 1882, p. 488).

This report attracted considerable attention at home and was reproduced and commented upon by nearly all of our leading journals; and some of our legislatures, notably those of Illinois, Georgia, and South Carolina, took up the subject.

I firmly believe that the great hindrance to the prosperity of the farmers of the United States to-day is the lack of good and substantial national, State, and county farm roads.

I do not think that this proposition can be assailed unless it is to be made stronger than my feeble powers can state it.

Wherever such roads have been constructed they have enhanced the value of the farmer's land, and have given increased value to all the products of his labor.

It is a common mistake that the farmer reaps all the benefits from good roads. While it is unquestionably true that the farmer is benefited in a hundred and fifty ways by good roads, in must be borne in mind that anything which benefits the farmer benefits the entire community.

Our farmers have to compete with farmers who have the very best facilities for hauling their product to the markets (at a minimum of labor and cost) and to the railways. Highways in Europe enable the farmer to carry immense loads to the markets with one horse which our farmers can not do in some instances at all, because the road is simply impassable. Our farmers can perceive the odds against them when a dog in Europe can draw a load to the market which a horse can not do in the United States.

This is a day of close competition in everything, and the farmers of

our country are realizing this. They have an immense advantage over the European farmers, and have reduced the latter to the practice of the very strictest economy in order to live at all. With economy and with the advantage of the excellent highways the European farmers eke out an existence, but they have learned by stern necessity that which our farmers must learn for protection.

If a highway can be provided by which a farmer can haul an increased load to the market with one horse that at the present time requires the services of two, with a larger and stronger wagon, and if this can be done in 1 day instead of 3 or 4, it is as palpable as a proposition can be that he is benefited just in that proportion.

How much this proportion is against our farmers will be seen when I state that some of our farm roads are absolutely impassable at certain seasons of the year, and four horses could not draw a load to our markets that one could easily draw to any market in Europe.

The European highways are crowded with pedestrians and with bicycles. This is true because the condition of the roads invite such exercise. In the Valley of Virginia we have an excellent road. During our civil war army wagons, cannons, and the tramp of soldiers which ground into slush a common road left this highway comparatively uninjured. Farms along this road are worth and can readily sell for 100 per cent. more than farms on the ordinary country roads. The farmers are in better condition, and if you were to tell them that you meant to deprive them of their road there would be consternation among them.

There is nothing more rational to my mind than the movement of the farmers towards bettering the condition that environs them. But this question of good highways that the Government will seemingly take up for them, judging from this circular, is a towering mountain before their very eyes, whose top is lost in the heavens compared with a microscopic atom with anything else that affects them. If they are given good roadways depend upon it half of what they complain of will be removed. If railroads may be compared to the arteries of a living body, then wagon roads are the veins, and each are equally necessary in quickening and in communicating life to the parts to which they lead.

From this circular I believe our Government is sensible of this obligation which we owe our farmers, and which our interest and civilization imperatively demand that we should pay them.

More than three hundred years before Christ the Romans recognized the importance of good highways and they saw that this was a subject of the very first importance to them. Historians have looked only to battles and the clash of arms and the great and stirring events in the epochs of nations, and have attributed this cause and that cause as contributing to the national puissance; but, in my opinion, nothing was more of a factor in Roman conquests than the splendid roadways that allowed her troops to be concentrated quickly and hurled with force on the enemy.

More than one hundred years ago English farmers arose and demanded good roads, and they continued to demand them until they got them.

There is not a state in Europe but has had good roadways for at least a hundred years.

We are then at least one hundred years behind Europe, and about twenty-four hundred years behind Rome in this important matter.

There is not a question but that we must have good highways.

Our Government owes this to the people; and believing this as firmly as I do, I have sketched out on a map,* which I have the honor to forward in this report, seven different routes of national highways.

I have adopted the Roman plan of drawing a straight line from point to point; and this, in my opinion, should be strictly adhered to in any system of highways we may build. Influence should not be allowed to twist, turn, distort, and crook such highways.

The first grand route, as will be seen from the map, is a direct one from Danforth, on the Maine frontier, to St. Louis, thence to San Francisco. This route should be the great national highway, and it should be 50 feet wide, with a row of shade trees on either side and one in the middle of the road, with watering places with fresh running water every 5 miles along the route.

The next route in importance on the map is that from Bangor, Me., via Portland, Boston, Providence, Hartford, New York, Philadelphia, Washington, Spartanburg, Atlanta, Montgomery, and New Orleans.

The next in importance will be from New York or Philadelphia direct to Cincinnati, Louisville, Memphis, Austin, and thence to the Mexican frontier at Ivias. The next grand route will be seen to be from Chicago direct to Salt Lake City, thence to San Francisco.

The next from Chicago to Cincinnati, thence to Wilmington. The next from Duluth to Helena, thence to Tacoma, thence to San Francisco, thence to Yumas.

The red lines indicate connecting routes of minor importance which should be built by the States or Territories through which they run.

I will not go to the trouble of defending, advocating, or championing this system. I will allow the plan as drawn to speak for itself. If we want our country settled up we should offer facilities for people to get to it in their wagons and on foot as well as by rail. Good roads is the best invitation for people to settle a country, and our enlightenment and civilization demand of us to furnish this means of communication, circulation, and exchange of products.

Convicts and paupers could not be better employed than in building and keeping up State highways, and this, it seems to me, would be the best and most practical employment for them.

Lord Macaulay attributes the wretched condition of the English highways at the beginning of the eighteenth century as "due to the

* Map not printed.

state of the law, which compelled each parish to maintain its own roads with statute labor." As this is the system principally in vogue in the United States, this may also be the reason of our bad roads.

The money expended on many of our good for nothing mud roads is absolutely thrown away. If we want good roads we must go to work and make them good, and then it is easy to keep them good; whereas if they are bad to commence with all the money spent on them is just the same as throwing it to the dogs. One hundred millions of dollars spent in making a first-class road saves two hundred millions in dribbles on roads that remain bad in spite of all amounts expended on them.

GEO. C. TANNER,
Consul.

UNITED STATES CONSULATE,
Pictou, November 29, 1890.

DOMINION OF CANADA.

BELLEVILLE.

REPORT BY CONSUL DENEEN.

I have the honor to make the following report concerning the streets of Belleville and the roads of Hastings County, Ontario, Canada.

The ground on which the city of Belleville is built rests on a limestone formation. In many places the stone crops out on the surface. There are 38 miles of streets in Belleville. To make them limestone broken by a crusher is employed. This stone costs $4.50 per cord at the crusher. A cord contains 4 cubic yards and 20 cubic feet. The cost per cubic yard therefore is 95 cents, and the cost of drawing and spreading the broken stone on the streets is about 30 cents per yard. Whole cost per cubic yard, $1.25. One cubic yard will suffice for 4 square yards. The cost is therefore 31¼ cents per square yard when the stone is spread on the street. There is a small piece of square stone pavement which cost $2.75 per square yard.

The sidewalks are made of pine planks, except a small piece of square block Nicholson pavement. The plank sidewalks cost 25 cents per square yard; the block pavement $1.10 per square yard. The sum of $9,000 is annually expended in building and repairing streets. It costs $3,500 to build new and repair old sidewalks each year. The remainder, $5,500, is devoted to building and repairing streets, culverts, and drains.

There are between 400 and 500 miles of macadamized roads in Hastings County. The stone of which they are made costs 45 cents a cubic yard. This will suffice for 4 square yards.

For these statistics I am indebted to James Taylor, supervisor of streets.

S. H. DENEEN,
Consul.

UNITED STATES CONSULATE,
Belleville, December 4, 1890.

BRITISH COLUMBIA.

REPORT BY CONSUL MYERS, OF VICTORIA.

Considering the recent date of settlement, the rough and uneven character of the surface of the country, and the limited finances at command, this province is remarkable, in the older portions especially, for its excellent roadways, and in all parts of it for the interest taken in them and for the amount of money expended in their construction. This has been brought about, first, by the necessity here for artificial roadways; second, by the abundance and variety of good material for roadmaking; third, by the good examples early set by the Hudson's Bay Company; fourth, by the Scotch taste, energy, and skill that dominate largely in governmental affairs in this province.

I have been unable to ascertain the exact per cent. of the total revenues of the province put into roads each year, but it must be a very high rate, and it has required courage to make such an expenditure of money. The total receipts of the province are less than $1,000,000 per annum, yet out of this meager resource and where the surface of the country is broken everywhere with rocky hills and narrow valleys, covered by a dense growth of Douglas and other firs, and further obstructed by dense underbrush, etc., fine roads wind everywhere, and in the vicinity of Victoria and the chief towns of the mainland they are the delight of tourists, and are among the principal agencies in opening up otherwise inaccessible forests and mines. How has this been accomplished?

COUNTRY ROADS.

In the first place and chiefly the provincial government has entire charge of all road work. I emphasize this point because, in my judgment, it is the key to the success of the system that prevails here. Road work is not left to local caprice, nor is it placed in the hands of incompetent or inexperienced persons. The department of lands and works determines where a road is needed, and then it is laid out by a competent engineer, and thus the roads of the entire province are related to one another. The government not only determines where the road shall be, but how it is to be made, who is to make it and what the cost shall be; and then it pays the bill out of the public treasury. There is no special tax or special road appropriation. The work of construction is under the supervision of competent civil engineers and foremen who have what may be regarded as liberal salaries. The latter receive from $100 to $150 per month. All work is done thoroughly and with great system, and the work of one year is the foundation for the work of the following year, according to the general plan of improvements.

There are two methods of prosecuting these public works. One is by contract, based on carefully prepared specifications. Roads are generally constructed in this way. The other method is by day labor, under the supervision of a government foreman, who is appointed by the department of public works.

Roads are divided into four classes, first, second, third, and fourth. A first-class country road may be described as follows: In width it is from 18 to 20 feet between ditches. In making it the trees and shrubs are first cut away in a strip 30 to 40 feet wide. The ground is then grubbed, and finally it is graded to a uniform surface, being crowned in cross-section 12 to 18 inches in the center. It is then paved with suitable crushed stone to a depth of not less than 6 inches, and it may be 9 or 12 inches. The width of this macadam is 12 to 15 feet. Over the top of this stone is spread a layer of good, coarse gravel to a depth of 6 to 12 inches.

Such a road costs from $3,000 to $5,000 per mile, owing to the size of the trees to be removed, the amount of grading and blasting, and the convenience of stone and gravel. The road from Victoria to Esquimalt Harbor, which is a little over 3 miles long, was macadamized at a cost of $4,000 per mile, but there was extra good work put upon it. In this vicinity the ordinary cost of earth excavation is 30 cents per cubic yard, and of rock excavation $2.75 per cubic yard.

Second-class roads are simply cleared of the trees, grubbed, and graded, and are usually about 20 feet wide in the clearing and 10 to 12 in the grading. They are not regularly macademized or graveled, and the cost is from $500 to $1,000 per mile.

Third-class roads are forest cleared and stumps close chopped, without further work. They cost from $200 to $500 per mile.

A trail is intended for pack animals only. The principal work done is to cut off trees and bushes a few feet in width through the forest, and blast pathways along the sides of precipitous hills and mountains.

The Government makes all the principal trunk lines and nearly all of the branches. It also owns and operates steam machinery, drills, and rock-crushers. Where rock and gravel are not available, corduroy, plank, etc., are employed. Roads in use are kept in repair by annual appropriations.

The following table will show the number of miles of each grade of road in the different districts:

District.	First class.	Second class.	Third class.	Trail.
	Miles.	*Miles.*	*Miles.*	*Miles.*
Victoria	61	21	15	....
Esquimalt	34	22	12	....
Cowichan	26	49	27	....
Nanaimo	66	54	44	39
New Westminster	228	127	50	....
Yale	467	151	61	300
Scillvoet	204	121	52	....
Cariboo	162	82	....	947

No distinction is made as to roads for heavy or light traffic. All the roads are used for all purposes required by the convenience of the people. In building rock is usually abundant, often a part of the excavation, and beds of gravel suitable abound in all parts of the province. If wood is required, such as poles for corduroy, or even plank, the supply is almost limitless.

These artificial roads add greatly to the value of adjacent lands and make settlements possible where without them men could not live.

CITY STREETS.

The streets and sidewalks of all incorporated towns and cities are constructed by the corporation, and are paid for by it, and the general plan of work is the same as that on first-class roads. The trees are removed, the ground grubbed and graded. It is then macadamized to a depth of 8 or 10 inches. Gravel is also used. The price of earth and rock excavations is about the same as in country districts. The cost of macadamizing 8 inches deep in Victoria is 65 cents per square yard. There are about 60 miles of graded streets in Victoria, forty of which are macadamized.

LEVI W. MYERS,
Consul.

UNITED STATES CONSULATE,
Victoria, December 16, 1890.

CHATHAM.

REPORT BY COMMERCIAL AGENT WEBSTER.

The roads in Chatham are made of stone, cedar blocks, and brick. The methods are as follows: Limestone set on a bed of sand 10 inches in depth has been in constant use for 30 years, its cost $1.25 per square yard for material and labor; round cedar block pavement on a bed of sand 7 inches in depth, cost 85 cents per square yard; its durability is 6 years. Brick paving is a new branch here; it is supposed to last from 10 to 15 years; it is made first as follows: A bed of fine gravel 7 inches thick rolled with a 6-ton roller, on which is laid one layer of brick on the sides; on them is spread 2 inches of sand, then one layer of brick on edge, after which roll all with a 6-ton roller; cost, $1 per square yard.

The best brick is made from iron slack, and is equal to granite, but most of the brick is made from ordinary top clay. I will add that this town took this pavement from Alliance, Ohio, where it is giving good satisfaction.

I am, sir,

W. H. H WEBSTER,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Chatham, January 6, 1891.

COATICOOK.

Owing to the primitive and ancient methods of building and maintaining roadways here there is positively nothing to learn. I have to inform you, however, that since the recent introduction of American road machines the public highways have been very much improved by their use.

ALFRED W. STREET,
United States Consul.

UNITED STATES CONSULATE,
Coaticook, January 2, 1891.

MONCTON.

There is neither street-building nor road-making in any part of my district; simply ordinary country roads.

The city council at Moncton are now considering the advisability of paving the main street, but it is impossible to say when such will be carried into effect.

JAMES S. BENEDICT,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Moncton, New Brunswick, December 11, 1890.

KINGSTON.

REPORT BY CONSUL TWITCHELL.

I have the honor to submit the following report. The report upon city streets is almost entirely the work of George Osborne, esq., one of the city aldermen, who is giving great attention to the improvement of city streets. The information of the public highways was furnished by Thomas Dawson, esq., for many years of the county council.

CITY STREETS.

The streets within the limits of the city are supposed to be macadam. Broken limestone forms the upper stratum of 8½ inches; some kind of rotten soft stone, here called binding, is then spread thinly over the surface, then the whole is rolled in with a heavy steam roller. When finished and as long as the weather is dry the streets are fairly good, but on the approach of wet weather the lack of stability is evident, and false economy is shown by the accumulation of mud formed on the wearing surface. Then again the underlying stones sink into the ground, causing holes to be formed; these holes hold water, the result being the road soon wears out and has to be constantly renewed. In

the first place, according to the best authorities, limestone is unfit to use on streets, because of its soft nature, but it is cheaper than any other stone to crush, and is also cheaper to roll, but the cost of repairing is frequent and great. The constant renewals and the abundant and excessive sprinkling, made necessary on account of the dust, tax the purse beyond endurance. Added to this the dust from the limestone streets is most unhealthy, as we must to some extent take it into our lungs in dry weather and we breathe its emanations in wet weather. During this year small portions of the city streets have, as an experiment, had a covering of granite chips spread over them about 4 or 5 inches deep and rolled in. How this will last can not be judged until next year.

The quantities needed for laying down limestone macadam and the cost in this vicinity are as follows:

On a block 264 feet long by 35 feet wide:

Rough stone, about 8½ inches deep, 30 tons, at $4	$120.00
Gravel, 3 inches deep, 11 tons, at $6	66.00
Binding (rotten soft stone), 7 tons, at $4	28.00
Spreading stone	25.00
Rolling	25.00
Total	264.00

Or 24 cents per square rod.

The quantities needed for laying down granite macadam and cost of doing same are as follows:

Rough limestone, 8½ inches deep, 30 tons, at $4	$120.00
Granite chips, 5 inches deep, 18 tons, at $12	216.00
Binding (rotten soft stone), 7 tons, at $4	28.00
Rolling and spreading	50.00
Total	414.00

Or 39 cents per square yard.

The conclusion to be drawn from the above facts is that limestone for streets is not good. The binding is worse than useless, as it all has to be scraped off in wet weather or is left on the streets as mud. No opinion can be expressed on the value of granite chips, as the experiment is only in its initial stage. Street building and repairing is under the direction of the city engineer, controlled by the city council. The expenses are paid from the city treasury.

COUNTRY HIGHWAYS.

In the province of Ontario the government in surveying new townships, establish the principal roads, known as concessions and base lines, and subsequently open up and construct roads leading from the older settlements, known as colonization roads. This work is provided for from a fund known as a colonization fund, set aside by the provincial or state government and drawn from the provincial exchequer. This fund appears in the estimates of the annual budget. Such work is usually performed under the supervision of overseers appointed by the depart-

ment, and is strictly a government work. Subsequently, as the township progresses from a colonization state, the roads come under the municipal control and are thenceforward opened up and kept in repair by statute labor, being in proportion to the assessed value of property, the number of days' labor according to assessed value, however, being fixed by statute law, and is not less than 50 cents or more than $1 per day, to be regulated by local municipalities. There is also what is known as a poll tax, which is an imposition of two days' labor upon all males between the ages of 21 and 60, respectively. This, however, is superseeded when a party becomes assessed. In many cases local municipalities have given to private companies the right to build macadamized roads and draw tolls therefrom. This system is a relic of a bygone age and is fast disappearing. Each local municipality strikes in their estimates a certain sum for roads and bridges, to provide planking for bridges, dig and construct particular culverts, or other extreme repairs which may arise from time to time.

M. H. TWITCHELL,
Consul.

UNITED STATES CONSULATE,
Kingston, December 23, 1890.

MONTREAL.

REPORT BY CONSUL-GENERAL KNAPP.

CARE AND MAINTENANCE.

The establishment, care, and maintenance of the streets of the city of Montreal are under the supervision and control of the mayor and board of aldermen of the city.

A subcommittee of the board numbering seven aldermen compose what is termed the road committee. This committee has the special supervision of the road department, at the head of which is the city surveyor. But while the said committee has special supervision of that department, still the mayor and board of aldermen have the general supervision and control of that department and of all matters relating to the establishment, care, and maintenance of the streets of the city.

The city of Montreal has for 2 years last past spent and is still spending large sums of money in the improvement of her streets.

During the year 1890 nearly $460,000 was spent in repaving certain streets, and for this purpose there was used four kinds of pavements, namely: "The wood-block pavement," "the block-stone pavement," "the Trinidad asphalt pavement," and "the Sicilian rock asphalt pavement."

The manner of laying each of the above kind of pavements and the cost of the same were in detail as follows:

WOOD-BLOCK PAVEMENT.

The blocks used for this pavement were the Tamarac blocks, live wood, sawed on all faces, made from 3-inch plank of the following dimensions, viz: 3 inches thick, 5 inches wide, and 6 inches deep.

The foundation for these blocks was made by excavating the subsoil and other matter to a sufficient depth and making a solid foundation.

Upon this foundation there was laid Portland cement concrete 6 inches thick.

The concrete was of the following proportions: One measure of Portland cement, 3 measures of clean, sharp river sand, and 8 measures of broken stone or macadam, which was new and broken to 2½-inch cubes, and was made and mixed as follows: One measure of cement and 3 of sand, mixed dry, and then made into a mortar with 20 per cent. of water; 8 measures of new broken stone was then immediately incorporated with the mortar, and rapidly mixed, and spread and thoroughly compacted by ramming gently with a wooden rammer (about 9 inches square), until free mortar appears upon the surface, which must be perfectly smooth and cambered to the same level as the finished road surface. This was allowed to remain 7 days before the paving blocks were placed upon it.

Upon this foundation the wood paving blocks, creosoted, were laid close together and on the surface a coating of hot coal tar and pitch was poured until the blocks would absorb no more; over this a coating of fine roofing gravel about 1 inch in thickness was spread.

There was during the year 1890 40,471½ square yards of this pavement laid in all, at a total cost of $120,486. Of this 26,243 square yards was laid by contract work, at an aggragate cost of $80,512, or an average cost of about $3.06¾ per square yard, and 14,228½ square yards by day work, at an aggregate cost of $39,974, or an average cost of about $2.81 per square yard.

BLOCK-STONE PAVEMENT.

The paving blocks used in this kind of pavement were of granite and Belgium porphyry, in length from 8 to 14 inches, in width from 3 to 4½ inches, all being of a uniform depth of 6 inches.

The foundation for these blocks was made by excavating the soil for a sufficient depth and making a solid foundation.

Upon that foundation was laid Portland cement concrete 6 inches thick. The concrete was of the same preparation as that used for the wood-block pavement above described. On this was laid a bed of clean, sharp river sand 2 inches thick. Upon this foundation the stone blocks were laid. Each row of block stone were of uniform width and depth, and so laid that all longitudinal joints were broken by a lap of

at least 2 inches, and the joints not more than half an inch. The blocks were then consolidated by ramming until they were in a firm, unyielding bed, with uniform surface, and when thus laid the joints were immediately filled with cement grout until the sand beneath the blocks absorbed no more and the joints filled flush with the surface of the pavement. The whole surface of the pavement was covered with clean, sharp river sand to a depth of 1 inch.

There was laid during the year 1890 32831 square yards, or 1¼ miles, of this pavement, at an aggregate cost of $133,722, or an average cost of $4.07⅓ per square yard.

ROCK ASPHALT PAVEMENTS.

The foundations for these pavements was made of the same depth, the same materials, and in the same way as the foundation for the wood-block pavement above described, to which reference is hereby made. Upon such foundation the paving asphalt was carefully spread in such a manner as to give uniform and regular grade and thickness, the wearing asphalt surface being 2½ inches thick when compressed.

Of these pavements there was laid during the year 1890 30,619 square yards, viz: Of the Trinidad asphalt 8,147 square yards, or one-third of a mile, at an aggregate cost of $27,954, or an average cost of $3.43 per square yard; of the Sicilian rock asphalt 22,472 square yards, or 1 mile, at an aggregate cost of $89,213, or an average cost of $3.97 per square yard.

Of the above-mentioned pavements the block-stone pavement is considered best for heavy traffic, while the asphalt is considered best for light traffic.

The cost of paving the streets of Montreal is paid by the city and not assessed against the property on the streets.

The cost of the above-described paving was paid by a loan negotiated by the city, and no part of the same was levied against the property adjacent to the streets so paved.

The cost of paving and maintaining the streets and roads of Montreal during the year 1890 was as follows:

Paving	$459,437
Cleaning	52,864
Removal of snow	17,557
Repairing	99,641
Watering	15,745

It may be proper to add that the city of Montreal is spending and contemplates the further expenditure of large sums of money in widening, paving, and otherwise improving its streets and roads in a manner most enterprising and creditable to the city.

Permit me to add that this report is confined to city streets, for the reason that the country roads in the province of Quebec embrace many road districts, each under local management. The maintenance

of these roads and the cost of the same depend upon the climate, the soil, and the requirements of traffic in each, and as I am informed that the same circular of inquiry has been forwarded to the several consular officers in the province, it is assumed that they will forward to the Department full and complete reports, being in possession of more detailed and accurate information as to the roads in their respective localities than is this consulate-general.

All of which is respectfully submitted.

CHAS. L. KNAPP,
Consul-General.

UNITED STATES CONSULATE-GENERAL.
Montreal, March, 9, 1891.

MORRISBURG.

REPORT BY COMMERCIAL AGENT SCHOFIELD.

MACADAMIZED COUNTRY ROADS.

I have talked with a number of farmers from different sections of my consular district as to the best kind of roads for the country, the mode of making them last longest, and the way they are kept in repair, etc., and they all agree that macadamizing made as follows is the most suitable for this section of country:

First prepare the place where the road is to be made, say 12, 18, or more feet wide, as may be required; then put on 12 inches at least of stone in the center of the road and 6 inches on the sides. The travel will be in the center of the road. The stone to be made fine by a crusher not larger than will pass through a 2-inch ring. Then cover with fine gravel or coarse sand, if the same can be had. This will help to cement the stones together and make them even, hard, and dry. Then there must be good deep ditches on each side of the road, to let the water pass off and keep the road dry. As the stone settles in the dirt put on more stones to prevent holes in the road.

EXPENSE OF ROADMAKING.

The first cost is, say, from $6 to $8 per rod. Sometimes, in a bad place, it will cost more.

Some of the roads are kept in repair by money from toll-gates, some by the statute labor of the parties living along the road, some by a tax on the county, some in one way and another as the different townships may see fit.

GENERAL EFFECTS OF GOOD ROADWAYS.

Good roads are a great benefit to any country and enhance the value of the land. They give the inhabitants at all seasons of the year the benefit of going to market to sell their produce and get their supplies. In

good sections of the country villages are built up, manufactories in a small way started, stores, post-offices, schools, and other public buildings erected, and when they have a water-power mills are built. This benefits the inhabitants, the country improves, travel is opened. All this from good roads. Without them a country will not improve much.

TOWN AND VILLAGE STREETS.

In towns and villages the public traveled roads are made as in the country. The sidewalks are mostly built of wood, as follows: Prepare the ground, say 4 to 12 feet wide, as may be required; then lay some stringers 12, 18, or more feet long, 4 to 8 or 10 inches square, to keep the covering from the ground; then put on 2-inch deal plank and nail to the stringers. In some places flag stones are used and in other places gravel, but in this section of the country plank is mostly used. Good ditches must be opened on the sides of the roads to let the water pass off so as to keep the planks dry. Where it can be done deep underground sluices are made to let the water off. These streets are properly made and kept in repair by a tax laid on the inhabitants of the towns or villages.

W. A. SCHOFIELD,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Marisburg, December 29, 1890.

NOVA SCOTIA.

REPORT BY CONSUL-GENERAL FRYE, OF HALIFAX.

Referring to the street and roadway circular of November 8 last, from the Department of State, I have to say in reference to the roads in Nova Scotia that for the most part they have been constructed in a manner similar to that usually employed in the country towns of New England, and are probably in about the same average condition. Within a few years, however, the importance of the subject of building and keeping them in repair has engaged public attention, and the road system of Nova Scotia has materially improved.

STREETS.

The city of Halifax, with its population of 40,000, is the only city or town within the province where the streets are constructed with engineering skill. Generally it is built upon and courses along a continuous range of hillside for a distance of over 2 miles. The principal streets run nearly parallel with its slope and the shore. The cross streets, laid off at right angles to them, ascend with inclinations varying from 1 foot in 10 to 1 in 15. In the suburbs the gradients are much less, the ground in some directions being nearly level. The cost of maintaining the streets where

the gradients are so steep is greatly increased. The rainfalls wash away the binding materials. The wear from horses, feet increases according to the power required for hauling. Even when well constructed such streets require to be often repaired.

The Macadam system of street making is that generally adopted. It is partly founded on a clay-slate rock in situ, partly on a substratum of broken slate and in some instances the "Telford" bottoming pavement is introduced. The Macadam system is considered the best for the steep gradients, for although it is liable to be torn by the horses' feet, it at the same time gives a more reliable foothold than a material likely to wear to a more slippery surface.

For the streets where the surface is more nearly level and the traffic greater the city contemplate the employment of paving. The city engineer recommends porphyry and granite paving in the usual form of dressed cubes, 8 inches by 4½ inches by 6 inches, to be laid on a substratum of concrete. The material for part of these blocks has been contracted for at the following prices: Belgium porphyry blocks, per square yard, $2.08; Nova Scotia granite, from the Shelburn quarry, $1.75. A quantity of each is to be employed to test the comparative merits, and that giving the best satisfaction after trial will be adopted. The ground work is to be prepared and the blocks set in place by "day's work," under the supervision of the city engineer.

The material used for macadamizing consists of a tough quartzite or whinstone, to be had within easy distance of the city at low cost. The stone is broken principally by pauper or convict labor. The poor of the city are thus furnished with employment by the "Poor Association" during the winter when nothing better is offered. Able-bodied convicts in the city prison are also made to perform such work. The city pays the association 7 cents per bushel for the broken stone, and to the city prison 3 cents per bushel. There are nearly 24 bushels in a cubic yard of broken stone. The demand for this broken stone is becoming greater than the supply, and a stone crusher is to be put in operation forthwith.

Very few new streets are being built in the city at the present time. Repairs are made by "day's work." The wages paid for such labor is from $1 to $1.10 per day.

In the year 1887–'88 the sum expended on the streets of Halifax was $19,230, and on street cleaning and watering, $12,923. In 1888–'89 the street expenditure was $22,484, and for cleaning and watering, $14,756. This does not include repairs to city property, from $1,500 to $1,700 more in each of those years.

For a great part of the information obtained for this report I am indebted to Martin Murphy, esq., provincial government engineer, an intelligent and efficient officer, who has certain supervision over the construction of roads and bridges in Nova Scotia. Having read some of his published papers on road and bridge building, I was the more de-

sirous of consulting him, and applying to him for certain information on the subject of this report he kindly furnished it in writing. To a considerable extent I have adopted the language used in his written answer to my inquiries.

PUBLIC ROADS.

Following is what he says on the subject of building public roads in Nova Scotia:

Nova Scotia, with a present population of about 460,000, an extreme length of 350 miles, breadth, 120 miles, and an area of 20,907 square miles, is provided as follows: The length of main roads in 1880 was 6,493, and of second-class roads 9,761 miles. Present length of main roads, estimated, 6,800 miles, second-class roads, 10,000 miles. Total, 16,800 miles.

The province is divided into eighteen counties having twenty-four municipalities, six of the counties having two municipalities in each.

In 1879 an act of incorporation conferred on every county and sessional district all the usual municipal governing powers, embracing laying out, construction, and maintenance of roads and bridges, the appropriating and apportioning of road and bridge moneys, employment of statute labor, and the regulation of ferries and public wharves. Since then the municipalities have received an annual appropriation from the government of from $90,000 to $120,000 towards the maintenance of roads and bridges.

In 1883 the old wooden bridges then existing had become so bad that an act authorizing a provincial loan of $500,000 was passed for rebuilding them with more permanent material, such as stone and iron. The reconstruction was carried out by the provincial government. Encouraged by the successful operation and results of this measure, the government provided two further grants of $250,000 each in the years 1885 and 1887, respectively, making an expenditure of $1,000,000 for the building of these bridges in a more substantial form.

In 1889 the roads throughout the province, under the supervision of the municipal councils, had become so bad that * * * it became necessary to make a special appropriation of $300,000 for better construction and repairs. The government took the work in hand, employed more skillful supervision, and effected such improvements on the great roads that in the session of 1890 a further appropriation of $300,000 was granted, to be expended in like manner.

The means available for the construction and maintenance of roads in Nova Scotia are derivable from statute labor and from government appropriation. The former source, although quite a factor if judiciously applied, is becoming almost useless in the hands of municipal authorities. Owing to the limited means at the command of the government for annual grants to roads the question of keeping them in good order becomes one of "how, with limited means, the best and most permanent results can be obtained." With such results in view one must be guided by the locality, the facility of obtaining suitable materials, and the traffic which the road is intended to accommodate. The nearest approach to the solution of this problem will be found by the employment of skillful supervision.

In a published article written by Mr. Murphy not long ago on "Our common roads," in referring to the transverse form of roads, he says:

Engineers differ as to the most advantageous form of cross sections, some recommending a convex curve approaching to the segment of a circle or semi-elipse, whilst others prefer two plains gently sloping towards the side gutters and meeting on the middle of the road by a short connecting convex surface. There are objections to both forms in certain situations. In the former, the convex road they are that the

water will stand in the middle; that carriages will keep in or near the middle and cause undue or excessive wear along one line in order to run on the level and avoid the tendency to overturn near the side ditches. In the latter that if carriages will not run along the center there must be, owing to the transverse inclination or fall from the apex or center towards the gutter, an undue tendency for the carriages or vehicles to slide upon the road surface. Regularity of section and evenness of surface is of much more consequence than the slight difference between curves and straight lines. It is essential that the rain should flow freely off the surface for the proper and economical maintenance of a road. Water standing in ruts or depressions must be avoided; it greatly increases wear, deepens and enlarges hollows, and weakens or destroys the whole crust of the road. Such a cross section should therefore be given as will throw the rain water off quickly, and the necessary inclination to practically effect the purpose must vary with the different material of which the road is composed. We can not have, as in Great Britain, one typical form of road, or method of road-making, because we must adapt ourselves to the materials at hand or within easy distance.

It is necessary to give a somewhat greater convexity to a new road than it is intended to have eventually; the middle consolidates more by the traffic and the surface material is scattered towards the sides, so that however carefully it is rolled or attended to the road will flatten as it consolidates.

Copies of drawings to show the forms of cross sections of roads as proposed by the provincial engineer are herewith submitted. Fig. 1 represents a cross section of Telford pavement, which can be made rapidly, and, with the drainage shown, forms a good road. Fig. 2 is a cross section covered with gravel or broken stone. Fig. 3 is a clay road with a 6-inch gr avel co vering, 8 to 10 feet in width, with a cente drain of stones. Fig. 4 is a clay road with a center drain of poles where stone can not be had. Fig. 5 is a cross section of road over a bog or marsh.

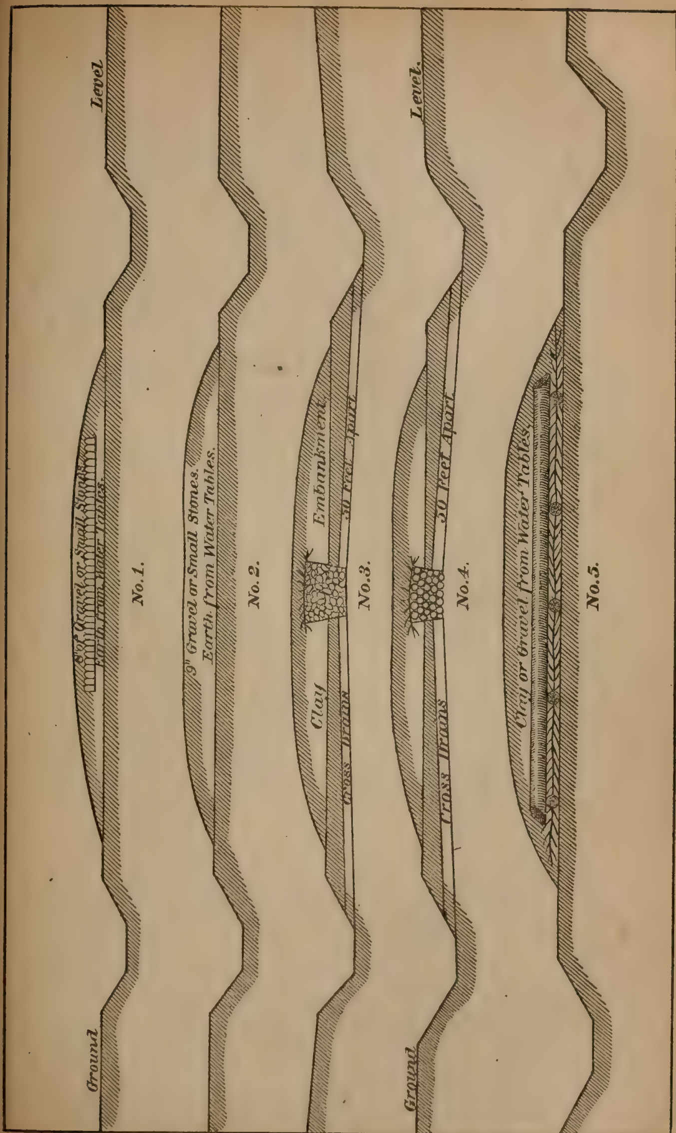
Roads with a drain running along the center, with outlets to the side ditches, have been tried on wet and soft ground, with favorable results

For general purposes, where the traffic is heavy, a well-drained road with the Telford pavement and macadam covering is recommended.

Liberal sums have been expended in bridge building within a few years. Iron bridges in many cases have taken the place of the old wooden structures. Generally the superstructures have been built on American plans, and in several cases American companies have built them on contract. Concrete as a substitute for stone for bridge supports has been used to some extent, and with marked success. The concrete hardens and improves with age, and it is believed that its use will be extended as its merits become better known.

WAKEFIELD G. FRYE,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Halifax, January 27, 1891.


Level
Ground
Gravel or Small Stones
Earth from Water Tables.
No. 1.
9" Gravel or Small Stones.
Earth from Water Tables.
No. 2.
Embankment
30 Feet Apart
Clay
Cross Drains
No. 3.
Level.
30 Feet Apart
Cross Drains
Ground
No. 4.
Clay or Gravel from Water Tables.
No. 5.

PORT STANLEY AND ST. THOMAS.

REPORT BY CONSUL HUSHER.

CITY STREETS.

The consular district of Port Stanley and St. Thomas is composed of Elgin County, and portions of the adjoining counties, in the province of Ontario. The county seat in Elgin County is St. Thomas, a city with about 11,000 inhabitants.

In this city there are three classes of streets, viz, cedar-block pavement, gravel, and graded earth.

The cedar-block pavement costs about 85 cents per square yard, and its lifetime is about 12 years; during that time very little repairs are necessary.

The graveled streets cost about 50 cents per square yard, but the cost of maintenance is very large. They are very objectionable on the principal streets on sanitary grounds, as it is almost impossible to keep a smooth surface and have the water run off.

Graded earth streets are only used for streets where there is but little travel.

The whole system of road making is carried through on the frontage system. A majority of the owners on the street has full power to decide what kind of roadway shall be put down, and the cost is assessed against the property fronting on the street in accordance with their frontage measurement.

The cedar blocks used are 7 inches long, laid on 6 inches of coarse sand or gravel, the surface being made the shape of the roadbed and then rolled with heavy rollers.

The only village of any importance in the district is Aylmer, with a population of about 1,100. In regard to the streets in this village, as also in the other villages in the district, the manner of making them and holding them in repair is the same as in St. Thomas. Outside of Aylmer there are, however, so far as I know, no paved streets.

COUNTRY ROADS.

Very little is to be said in regard to the country roads and highways in the consular district of Port Stanley and St. Thomas. The so-called "gravel road" from Port Stanley to the north line of Elgin County, a distance of about 13 miles, is leased out to an association which has to keep the road in repair, and therefore collects toll. The same is the case with the road between St. Thomas and Aylmer, a distance of about 12 miles. It has been tried to abolish the tolls on these two roads, but as the association is unwilling to give up the lease, it can not be done before the lease expires.

The other roads are opened by the county, and consist mainly of graded earth roads, in some places covered with gravel. The repairs

are done by statutory work, viz, each farm is assessed a certain number of days' work a year on the road. The work consists mainly in filling up mudholes and smoothing the surface of the road.

F. A. HUSHER,
Consul.

UNITED STATES CONSULATE,
Port Stanley and St. Thomas, December 22, 1890.

PORT HOPE.

REPORT BY COMMERCIAL AGENT SHAFFER.

In the district immediately covered by this commercial agency the streets in the towns are in some instances macadamized, but in the majority of cases simply built up of gravel. These are generally scraped with a road scraper in the spring and fall, and the result is that even with a minimum amount of drainage facilities the roads are generally good at all seasons of the year.

There are some block and asphalt pavements but not over large areas and only in the large cities of the province, and in these this class of pavement is not considered a success by reason of the severity of the winters.

In the rural districts the roads are built up of gravel put on from year to year, and this generally forms a good road during ordinary average weather. In wet seasons, however, they suffer much from soakage; and as the construction is generally done by "statute labor" it is not as a rule very thoroughly or effectively done. Where the soil or ground bed is either very light or of a clayey nature this class of road suffers much in both the spring and fall; in many cases when the frost is going out of the ground the roads are quite impassable.

It is almost impossible to ascertain the average cost of constructing the roads built as they are in the way above indicated.

There are no cities within this commercial agency, except by courtesy.

L. M. SHAFFER,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Port Hope, December 31, 1890.

PORT SARNIA.

REPORT BY CONSUL PACE.

CITY STREETS.

In reference to city streets nothing in the way of novelty can be reported from this or other cities in western Ontario. We have here the ordinary wooden pavement made by standing cedar blocks on end

and filling the interstices with sand and gravel; formerly a coating of hot tar was applied to the blocks before introducing the gravel; now the tar is generally omitted; latterly in putting down these pavements the excavation made to receive the blocks is first covered with white pine boards, closely joined together. This plan is doubtless an improvement over the former method of placing the blocks upon sand merely. The subject of street paving receives considerable attention just now in this country, and different methods are being tested. An experiment was tried in this town about a year ago in the endeavor to introduce the "asphalt" pavement. This process consisted first in a layer of broken stone or cobblestone, a coating of hot tar, then a coating of fine gravel, and finally a coating of a combination of "asphalt" and sand, applied hot; this last coating is heavily pressed by a large heated iron roller. I witnessed the construction of one such pavement, which has now been laid about 14 months, and its present condition is not such as would impress one favorably with this method. The cobblestones remain almost entirely denuded of the coating of asphalt and sand to which they were originally subjected. This pavement may have been improperly constructed, or possibly the material forming the combination of "asphalt" and sand may have been improperly mixed; whatever may have been the cause, it is apparent the result in this particular case is a failure. Cedar pavements in this climate when properly laid endure about 10 years, yet many of the blocks require to be replaced at the end of 7 or 8 years; much of course depends upon the quality of the cedar used, and great care should be observed in selecting the lumber upon which the blocks are made to rest. If the material is sound and free from what is known as sap, a cedar pavement, properly constructed, ought to last 10 years and even more.

COUNTRY ROADS.

The country roads of Ontario and especially in the older settled portions of the province are really very excellent roads. Their manner of construction is simple, although it differs somewhat in the different localities. In the vicinity of stone quarries broken stone or the refuse from the quarry is used as the first layer in constructing a roadbed; this material is thoroughly pounded into the earth and coarse sand and gravel are added, making a mass several inches in thickness. At first the loose sand and gravel is almost impassable for loaded vehicles, but the continued tramping of horses' feet and the frequent pressure which it receives from passing wheels soon renders the roadbed smooth and hard. In localities remote from stone quarries and where cobblestone are not easily obtained, ordinary sand and gravel is the sole material used in forming a road bed. Whatever may be the material used, whether broken stone or cobblestone, with sand and gravel combined, or sand and gravel without the foundation named, it is essential that

the roadway should be properly constructed with reference to grading and ditching or drainage. This is accomplished by excavating deep, flaring ditches at each side of the roadway (where the road passes through level or flat land), and the construction at intervals of wooden or stone culverts or sluiceways, in order that the surplus water may be turned aside or conducted away from the roadbed. When broken stone or cobblestone is used as a foundation an excavation is made in the center of the roadway, between the two ditches, to the depth of several inches and as wide as may be required to build the road; this excavation is filled with broken stone or cobblestone, in the manner before described, with the addition of sand and gravel, and when the roadbed is completed it shows gradually sloping sides from the center each way to the ditches on the margin of the road.

In many instances very durable and substantial roads are constructed without the use of broken stone or cobblestone, and these roads are built in the easiest and simplest manner possible. No excavation is made in the center of the road to receive the material; the sand and gravel are applied to the surface of the road without preparation precisely as they leave the gravel pit; the gravel is strewn over the surface to the depth of from 4 to 6 inches. The ditches and culverts and even the grading should be as carefully constructed in this method as the other; but it will be readily seen that this process of road building is much cheaper, both in material and labor, than if cobblestone or broken stone are used as a foundation. The loose sand and gravel thus spread over the surface of the road soon becomes hardened and smooth by the tramp of horses' feet and the continued passing of vehicles; a new coating of gravel is applied each year for a few years, and thus the hollow places become filled and the roadbed itself becomes more solidified. In fact, roads built after this method and properly cared for soon become practically indestructible. During the first 2 or 3 years after the gravel is applied hollow places will appear here and there, in the roadway, occasioned perhaps by the more yielding quality of the earth in some spots than in others. These hollow places are filled with a fresh supply of gravel, perhaps once each year, until the whole roadway assumes an unyielding surface, as firm and as smooth as the neighboring rocks. Whilst driving over these magnificent country roads, observing their solidity and comparative cheapness of construction, I have often thought our city street-pavers might learn useful lessons in the art of road building from these unpretentious tillers of the soil.

SAM'L D. PACE.

UNITED STATES CONSULATE,
Port Sarnia, January 15, 1891.

QUEBEC.

REPORT BY CONSUL RYDER.

COUNTRY ROADS.

The ordinary country roads throughout the Province of Quebec are not on such an improved scale as to invite favorable comparison with any of our most unfrequented roadways in the United States.

Roads over which there is travel to any great extent are usually "turnpike," and these have been largely absorbed by a "turnpike trust." The stock was eagerly subscribed to, as the investment was considered a desirable one, but such a heavy debt was contracted at the formation of the monopoly that it has been struggling under the load ever since, and has been unable to pay dividends to any extent.

These companies have been, in many instances, subsidized by the provincial government to a considerable amount. It was one of the promises of the present administration, made during the recent campaign, that, in the event of success at the polls, all turnpike roads and toll bridges should be purchased by the Government and made free.

An exit can not be made out of this city without passing through one or more toll gates controlled by this trust, where the fee charged varies from 10 to 25 cents per vehicle for each gate. As a general rule these turnpike roads are very good; they are usually the original roadways made by the Government, which have been acquired by a stock company under charter.

These roads are built much the same as an ordinary macadamized road, being excavated to the depth of 2 feet, and then filled with large stones for about 18 inches, the crevices being filled with smaller stones, then broken stones about the size of walnuts are used to even the surface, and the whole covered with a stone dressing and graded so as to afford sufficient drainage for all surface water to flow toward the ditches on either side. This is thoroughly rolled with an ordinary horse road-roller, weighing about 4,000 pounds. After properly constructing these roads there is a very small outlay for repairs, as the travel is not of a heavy class of teams, excepting during the harvest season. The cost of building turnpike roads after this plan is about $1.25 per square yard.

CITY STREETS.

The streets in this city are of two distinct classes, and may be styled the "ancient" and the "modern." The former are located in the older portion of the city, called the "lower town." These are planked with 3-inch pine deals laid lengthwise, and are very narrow, the entire width (both for carriage and foot travel) being from 8 to 12 feet. Where there is a footwalk it is made by placing 3 by 4 pieces, 3 feet long, and covering, with 3-inch pine planks, one side of street only. This style of roadway was decided upon, as there was only surface drainage, and

every refuse was washed to the river over this planking. It is very slippery, and no uncommon sight to see a horse slide on "all fours" for a distance of 25 feet before being able to recover his footing. These pavements are being slowly replaced by stone blocks, and are to be seen only in the most primitive portions of the city.

The upper town is better provided with good roads. The system which has been adopted is open to criticism from a sanitary point of view, and involves much labor and expense. The city engineer has made a special study of the matter of street-paving, and considers this the best adapted to the needs of Quebec, the most durable and also the least expensive.

The street is excavated to the depth of 2 feet, properly graded and rolled with a horse road-roller; then a foundation is made of wooden flooring of 1½-inch boards laid longitudinally and crossed at right angles by a second flooring of inch boards, so as to conform more readily to the required crown of the roadway. These are laid with one-half or three-fourth-inch spaces between, so that should any surface water penetrate it will not remain and freeze, but run through and be absorbed by the subsoil after passing through the layer of sand which is strewn over the flooring to the depth of one-half an inch, which is to prevent the blocks coming in contact with the flooring. This double flooring is the means of distributing the weight of passing loads over an extended area, and also prevents any local settlement of the surface. On the flooring is laid blocks of red tamarack about 12 inches long, as sawn from the log, about 10 to 15 inches in diameter, and placed on end. In the spaces formed around the blocks small pieces of wood are forced, thus filling in and tightening the mass. The interspaces remaining are then filled with a grouting made of sand, cement, and tar, or a mixture of finely-sifted coal ashes and cement. The surface is evenly rolled and covered with sand, which is allowed to remain until every cavity is filled, when the street is swept clean to the blocks.

These roads are very durable; pavements laid 35 years ago were recently taken up, and the tamarack blocks had not shown any signs of decay, but had worn down to about one-half their original length. The surface was as hard as stone. It is said that there is more resistance to this surface (to traffic) than stone, because stone, under the influence of water and the constant teaming, wears away like a grindstone; the vertical pores of the wooden blocks fill with grit, and the fibers of the wood, like the bristles of a brush, sway to and fro with the traffic in opposite directions without breaking.

The blocks are used in their green state, with bark on, which prevents the wood from coming in contact with the filling, and the bark lasts for many years. Great precaution is taken to cut down the tree in proper season, after its sap has all been reduced to fiber and before the spring sap begins its ascension through the pores of the wood.

The cost of this block pavement is from $1.50 to $1.75 per square yard.

FREDERICK M. RYDER,
Consul.

UNITED STATES CONSULATE,
Quebec, Canada, December 22, 1890.

MEXICO.

NORTHERN MEXICO.

REPORT BY CONSUL-GENERAL SUTTON, OF NUEVO LAREDO.

CITY STREETS OF MONTEREY.

The only city in this consular district which has paved streets is that of Monterey, the capital of the State of Nuevo Leon. In that city are some 13 miles of stone pavements. This paving is done by the city, and as much of the work is by convict labor it is not possible to give close approximate values of the cost.

In the better class of this work the process of making is as follows: The ground being leveled, with a slope to the center of the street, coarse gravel is spread over it, and cobblestones averaging, say, 6 inches in diameter are packed in, and more gravel with mortar packed in around to hold them in place. In the center or on the side is a narrow trench to carry off the water from showers. This is often made by laying a long flat stone underneath, with two others, one on each side, on edge, setting up high enough to carry the current. The cobblestones are held in place by setting thin slabs of limestone on edge, and then running at an angle from the center down to the sidewalk. In the climate of Monterey this pavement, when well made, lasts a long time, but from necessity is extremely rough. There is not a paved street in the city of Monterey which is not so rough as to make carriage-riding extremely uncomfortable. Enough of the black soil gets on the stones to make them extremely slippery when wet.

The sidewalks are usually narrow and set 6 to 8 inches above the level of the street. Limestone slabs are set on edge outside, while the sidewalk itself is made of the same stone laid flat, or small cobblestones, or of a sort of mortar called here *tepachil.* The latter is the most durable. It is also much better suited for walking. It is made by preparing a sub-bed of 6 inches of good sized stones with gravel to fill in the interstices; above this a fine sand is laid on and pounded down, and on this a sort of mortar made of fine sand and lime is spread and pounded down. When this is nearly dry it is hand-rubbed with a piece of fine-grained stone until it is water proof and quite smooth.

Most of the houses in Monterey are only one story, and the ground

floor is made largely of this same *tepachil.* I saw recently the floors of one house which were laid of this material more than 30 years ago, had been in use every day, on which no repairs had ever been made, and which are apparently as good as when first made. Water can be freely sprinkled on it, it will hold great weights, and is an admirable floor in all respects, except that it is cold and in damp weather the dampness which rises from it is a fruitful cause of rheumatism and similar diseases.

Sidewalks made of cobblestones have a similar foundation, and the small stones above are mixed and pounded in with mortar. I asked of various persons the cost of sidewalks and floors, and found that the price, always very low, varies from $1 to $3 per square meter, according to the care taken in the work, depth of foundation, etc. In some houses the dirt was removed to the depth of 6 feet, and large stones packed in as closely as possible, and the interstices filled with gravel, and above finely sifted sand. The mortar was more carefully made and pounded and also given more time to dry. There is an abundance of limestone, which splits in good shape for pavements, and labor is so cheap that the prices for the work are very low. I noticed that one of the new smelters has on its main floor this *tepachil* and that it serves its purpose admirably.

There is a great need for smooth streets in Monterey, and the limestone could be laid in small blocks in its native mortar so as to make excellent streets. This *tepachil* floor is used in many portions of northern Mexico. Formerly, flooring could not be obtained, and now it is so expensive that its use is very much restricted.

In this city, Nuevo Laredo, all the paving done consists in leveling the streets and spreading gravel on top. The sidewalks here are of brick or flat stones, or tepachil. Each person makes his own sidewalk, and there are no strict rules enforcing uniformity of height, width, or material. Mostly they are very narrow, rough, and only better than the mud or fine dust.

COUNTRY ROADS OR HIGHWAYS.

The highways of northern Mexico are in a very primitive condition. Owing to the great geographical area and the sparseness of population it has not been possible to expend much money in bridging streams or improving the original condition of the first roads. In the time of the Spanish dominion, considerable was done in making a few main highways from one principal city to another. Until within a very few years little attention has been paid by the Mexican authorities to this very important matter. Streams have been forded and bad places in the roads avoided by going different routes. During the last 6 or 8 years the matter has received more attention, and several of the States in Northern Mexico have made good beginnings on some roads which were most needed. In this work, however, they have been greatly hampered

by lack of funds, as all the available taxes are usually expended for other purposes.

The Federal Government has taken measures to bring this subject to the attention of the State authorities, and while very little has been done, comparatively speaking, and the roads as a whole are in a lamentable condition, yet the public and official mind is fairly awakened to the need of improved roads, and if funds were available the work would be promptly taken in hand. The railways have now reached so many of the principal cities that side roads and roads from mines, haciendas, etc., to railway connections are of special importance.

Owing to the geographical and financial condition, Mexico has a much more valid excuse for the neglect to improve the highways than has the United States. In the latter, especially in the older States, there has been for many years sufficient money, but no educated public sentiment as to the great importance of the work.

Within the last few years several states in northern Mexico have appropriated sums of money to build bridges and repair others and improve portions of the highway. Some municipalities have also made a beginning in this direction. So far, it can not be said that any well-considered system has been adopted and continued in this work.

WARNER P. SUTTON,
Consul-General.

UNITED STATES CONSULATE,
Nuevo Laredo, February 11, 1891.

NOGALES.

REPORT BY CONSUL SMITH.

CITY STREETS.

The materials used for street construction in this place, are the ordinary gravel, rock, and dirt, but no special effort is made to put and keep the streets in repair. This system of construction prevails in all the important towns of this consular district, and as there is but little pleasure driving in these towns, there is but little use for better streets.

COUNTRY ROADS OR HIGHWAYS.

The country roads are all natural highways and for the most part are very good, considering that but little work is done on them. There are now and then bridges crossing streams, but generally the streams are small and are forded. The natural roads of this country are quite noted for their excellence, and for the most of the year are smooth and hard. They usually follow the open cañons and often in making a journey of 20 miles, one encounters nearly every point of the compass,

or in other words, the roads are tortuous, and frequently one travels 4 or 5 miles to make a distance of 2 in an air line.

DELOS H. SMITH,
Consul.

UNITED STATES CONSULATE,
Nogales, December 2, 1890.

PASO DEL NORTE.

No macadamized or paved streets in this city. They are kept in repair by prisoners under the direction of police officers.

No improved public roads in this consular district.

But little work of any kind done on them except by volunteer work, as necessity requires, and by prisoners from the city jail.

A. J. SAMPSON,
Consul.

UNITED STATES CONSULATE,
Paso del Norte, December 3, 1890.

PIEDRAS NEGRAS.

REPORT BY CONSUL FECHÉT.

Within the limits of this consular district, excepting perhaps the city of Parras, there is not a paved street or roadway. In Parras cobblestones were used and at an early date, so that an estimate of cost would be difficult to arrive at. The towns and villages of this district have simple dirt roads, with a footpath at each side, generally made of packed soil. These roads are very dusty or very muddy, according to prevalence of drought or rain.

In the country no attempts are made at road-making, save an occasional bit of turnpike and ditch in low, undrained spots.

Generally it can be stated that, in this consular district, there are no paved streets or maintained country roads, as in the United States, and hence my inability to report anything of value to those desiring information upon the streets and roadways of foreign countries.

EUGENE O. FECHÉT,
Consul.

UNITED STATES CONSULATE,
Piedras Negras, December 23, 1890.

SONORA.

REPORT BY CONSUL WILLARD, OF GUAYMAS.

In this consular district (Sonora) there is but little to report as to the construction of "city streets and country roads or highways which is germane to the subject of improved roads."

CITY STREETS.

The streets of the cities and towns of Sonora can not be said to be expensive to construct or keep in repairs. The cities and town sites, as a rule, are located on level or comparatively level ground, the soil, according to the locality, being of rock, sand, gravel, and clay. In the four important cities of Sonora (Hermosillo, Guaymas, Ures, and Alamos), whose united population will not exceed 50,000 people, there are but few improved streets, and they will not, in the aggregate, exceed 8 miles. The streets that are improved are paved with cobblestones, and flat stones laid in sand, and are not fitted or intended for heavy traffic. As a rule these paved streets are confined around the public squares or parks (generally located in the center of the city) and approaches to the same, suitable for light traffic only; when repairs are needed the city authorities (city council or ayuntamiento) order it done, authorizing the expenditures necessary for the purpose.

COUNTRY ROADS AND ROADWAYS.

The highways and roads throughout this consular district can be classified as natural roads, and seldom laid out with engineering skill. The bridlepath or trails made and used when the country was first populated (or old Indian trails) from one small settlement to another became (in the course of time as the population increased and wagons were introduced, the trees and undergrowth of bushes were cut away to widen the bridlepaths and trails) roads over which the cumbrous ox carts and wagons which were first used could pass. The persons who made most use of the roads, with their wagon trains, made the necessary repairs to keep them transitable. As land was of little value, and most of it (at one time) public land, there was no difficulty or question as to the "right of way." The land not being fenced or inclosed, excepting to small extent near the settlements once established, these bridlepaths and roads became highways for public trade. To-day in Sonora these roads between the villages, towns, and cities are kept in repair principally by the owners of freight teams and stages. The country not being fenced, if a portion of the road from excessive rains or other causes becomes impassable, a road is made around the bad places by cutting away the brush and trees and leveling the ground so that wagons can pass. When streams of water are met (there are no

large rivers in Sonora) they are forded at the shallow places. In among the valley lands (which are the only lands cultivated) if the land-owner wishes to utilize what has been used as a highway he must provide a roadway for the public around the edge or border of the land, or fence on either side of the road (before used). In some parts of Sonora work has been done on roads by the authorities of the district calling on the owners of the land to assist in grading or straightening the same. In other parts a road tax is levied on the landed proprietor and is paid, either in money or work, for a few repairs indispensably necessary. There are no macadamized roads or toll roads, or bridges over which tolls are charged, in Sonora. There are bridges, but there are none over one span, and these principally over irrigating ditches, the said bridges erected by the owners of the ditches.

As this consular district is but sparsely populated, and the roads over which the freight wagons and stages travel not being in mountainous districts, no especial road laws are carried out systematically by the State government.

A. WILLARD,
Consul.

UNITED STATES CONSULATE,
Guaymas, December 1, 1890.

TAMPICO.

REPORT BY CONSUL LIEBERKNECHT.

There is not a street in this city fit for a carriage to drive over. The streets are all paved with small cobblestones and set not over 6 inches in the ground, without any kind of a foundation.

There are no country roads whatever in this section of country, nor wagons or carriages. Everything is carried on horse or mule back, and by water in canals.

Trails take the place of roads here.

A. LIEBERKNECHT,
Consul.

UNITED STATES CONSULATE,
Tampico, March 16, 1891.

TUXPAN.

The streets of this port are such crude affairs, being rocks of all shapes and sizes simply laid in earth, having no uniformity as to level, and being left entirely to the property owner who is obligated to clean and repair not only the sidewalks but to the center of the street, public roadways are not more than paths which, owing to the entire

traffic being done by pack mules and Indian porters, are only kept open by the people living on same who are required by law to work 3 days every year cleaning out weeds and overhanging boughs.

These roads are never graded, and no vehicle could or ever has passed over them; in fact, during the rainy season they are almost impassable by man or beast.

JOHN DRAYTON,
Consul.

UNITED STATES CONSULATE,
TUXPAN, *December* 6, 1890.

CENTRAL AMERICA.

NICARAGUA.

REPORT BY CONSUL NEWELL, OF MANAGUA.

CITY STREETS.

After thorough inquiry and careful investigation I have to report that the streets and roadways of Nicaragua are of the most primitive character.

The streets show that very little labor has been expended upon them. The nature of the earth forming the streets is such—volcanic formation—that it makes a good hard street without the necessity of artificial means being used to improve it. So hard and firm is this earth that, notwithstanding the long rainy season of the country, it does not form into mud; the water flows over it as if it were asphalt or macadamized.

The streets of nearly all the cities of Nicaragua are laid out and made in the same way. They all have the peculiarity of running for a short distance on a perfect level, then rapidly rising by a steep incline to a second level, and so on. This steep incline is paved with cobble stones or broken pieces of rock, so as to enable teams and horsemen to ascend or descend without danger.

In the city of Leon an attempt, in a small way, has been made to pave some of the streets. Cobble stones, and square blocks of stones, somewhat similar to Belgian blocks, have been used, but the distance paved would not exceed the length, on any one street, of 500 feet.

So little expense attends the building or maintenance of the streets of Nicaragua that it is almost reduced to a cipher.

COUNTRY ROADS.

The country roads are made by cutting down the trees and the small undergrowth, and removing from the way of the proposed road the large rocks. Outside of this manner there is no other adopted in this coun-

try. The cost of building roadways in Nicaragua it is impossible to arrive at, as there is no data kept of these matters.

WILLIAM NEWELL,
Consul.

UNITED STATES CONSULATE,
Managua, March 5, 1891.

SOUTH AMERICA.

BRAZIL.

BAHIA.

REPORT BY CONSUL BURKE.

COUNTRY ROADS.

There are no country roads, and but very little can be said of "city streets."

Communication between towns where there are no railways to the interior is by water in small boats or canoes, or by bridle paths on donkeys, mules, or horseback. To go in a carriage of any description 5, 10, 20, 40, or any number of miles, few or many, into the interior, is a thing unheard of and unknown; and this for two very good reasons, viz: First, there are no roads for a carriage, and in the second place there are no carriages, excepting those owned by livery-stable proprietors, and these are rarely used except for funerals, weddings, and baptisms.

In this city of 200,000 inhabitants, perhaps, there are not over five families that have their own turnout. All the merchandise sent from this city to the interior of the State must be taken to some seaport in small craft and then sent by rail, by river, by donkey, mule, or horse to its destination. Very little is sent by rail, as the number of miles of railway in this State and Sergipe is very limited, so that nearly all the merchandise imported, as well as the exported, products must be taken by water up or down the river, and by donkey or mule, simply because there are no roads.

From the city of Bahia to the southwestern part of the State it requires at least 30 days to make the journey. The journey by rail is 450 kilometres,* thence by horse or muleback to the San Francisco River, up the river in a small boat, then again by mule, donkey, or horseback till the town in the interior is reached.

Some idea of the difficulties and vexatious delays in traveling in this country may be obtained when it is known that to cover a distance some

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* 1 kilometre = 0.62135 of a mile.

200 miles less than from New York to Chicago (24 hours), it takes 30 days in this district—days of discomfort not only in the actual traveling, but also in the eating, drinking, and sleeping. The people are very hospitable, so it is not from this cause the discomfort in traveling arises. It is simply because actual comfort in going from town to town, such as one finds in the States, has never existed here; consequently neither the country nor the people can give what it has not. When one leaves the rail or the boat he simply mounts his horse, mule, or donkey, having provided a guide if not familiar with the country, and follows the trail, for it is nothing more, till he reaches his destination.

Women who find it necessary to travel must adapt themselves to the same conditions as the men.

CITY STREETS.

Of the streets of the city of Bahia, I can say that in general the pavement is very bad and very rough.

The principal street in the lower and in the upper town is the best paved in the city. Nearly all the other streets, with a very, very few exceptions, are wretchedly paved and very badly kept.

About 20 years ago the principal street in the lower and upper city was paved with stone, brought from Rio de Janeiro. It is, I should say, the ordinary paving stone consisting of blocks from 8 to 12 inches in length, from 3 to 6 wide, and from 4 to 6 deep. There was no attempt at system in paving the other city streets evidently, as all sorts and all sizes of stone are seen. One street called Ladeira da Barra was macadamized recently, and a sidewalk of the same kind made and covered with Portland cement, to give it a smooth surface. There is very little teaming done in the city. Nearly all the merchandise in the lower city, is moved on the heads of negroes, or on a four-wheeled vehicle, small wheels, all of the same size. These wagons, if such they may be called, are chiefly employed in removing merchandise from the custom-house to the different stores or import houses. This wagon is drawn by negroes. There is also in use a two-wheeled cart, called a carroca, drawn by a mule, upon which may be placed 4 or 5 barrels of flour or its equivalent in weight of some other article or product. This little four-wheeled wagon and the carroca constitute the entire wagon traffic of the city, so that a street well paved will last here for years without repair. Whenever heretofore any street required paving the work was done under contract from the municipal government. Repairs whenever made were under police authority, but now a company has been formed under the name of "Companhia de Calceteiros," or paving company. This company has received from the municipal government instructions as to what shall be done in the line of paving the streets, where it shall be done, what new streets shall be laid out, which ones shall be repaired, prices paid for work, etc.

The wages established by the day, a day of 10 hours, are as follows:

	Milreis.*
Superintendent	3
Assistant	2½
Foreman	2
First-class pavers	2
Second-class pavers	1⅘
Third-class pavers	1⅗
Attendants	1½

Payment to employés must be made weekly. If any work should be done under contract by this company the prices fixed are from 400 reis (21.8 cents) to 1,800 reis (98.3 cents) per square metre, depending upon the size of the stone laid. If flagstones are laid for walks the price is 16 milreis per cubic meter. If the walk is of brick, the price is 22 milreis per cubic metre. The price of the material depends on whether it is imporor or not, it also depends upon where material is obtained; the difficulty and expense in getting it, the quality of the stone employed in construction, and other things that have a tendency to raise or reduce the price.

Rent is naturally higher on the best streets of the city, where, as a rule, the houses are in a much better condition than in the poorer city streets.

DAVID N. BURKE,
Consul.

UNITED STATES CONSULATE,
Bahia, January 20, 1891.

PORTO ALEGRO.†

The street superintendent to the president of the municipal council, translated and transmitted by Consul Negley, of Rio Grande do Sul.

In obedience to the official order of the 29th of January last, No. 22, by which I am directed to answer the questions asked by the citizen consul of the United States of North America, I answer as to the first question, What material is used in the construction of the streets? In order to give a satisfactory answer to this question it should be borne in mind that the city is built upon an eminence, which is divided into three sections, a high section in the center, a low section to the north, and a low section to the south. In the high section the material employed is a mixture of two-thirds sand and one-third clay for the construction of the bed, because the ground is gravelly and in part rocky, and on this bed are placed granite stones of irregular sizes, from 15 to 20 centimetres in width and from 10 to 15 centimetres in depth, placed well together one against the other and covered with a light layer of sand, in order to fill up the small crevices occurring in the laying of the stones. As to the low part of the city in the north, where the ground is composed of a filling of soil, the work is the same, with the difference that in place of one-third clay for the construc-

*1 milreis = 54.5 cents.

†Porto Alegro, a city of 50,000 inhabitants, situated in the northern part of the State of Rio Grande do Sul.

tion of the bed, it is entirely of sand. In the southern section, where the ground is sandy, the stones are merely laid down in the same way as if the bed had been artificially prepared, except that in the clayey places the same method of laying the stones is followed as in the higher sections.

As to the second question, What does the material cost? Stone, Rs. 4$000 ($1.60, exchange at 40 cents to the milreis) per cubic metre; clay Rs. .640 (25 cents) per cubic metre; manual labor 1$100 (44 cents) per square metre; amounting to Rs. 1$600 (64 cents) per square metre for material and labor.

As to the third question, In what manner are the streets made? This is answered by the response to the first question, adding, however, that the new streets are made 17.60 metres in width.

As to the fourth question, Is there any difference between streets for light traffic and for heavy traffic? None, absolutely. There is, however, the inconvenience that the streets for heavy traffic are soon worn out, when they are immediately reconstructed *de novo*, always by the same system.

As to the fifth question, What is the depth and on what foundation are the streets made? In the high part of the city where the ground is gravelly or rocky, 30 centimetres, and in the low section on the north side, 50 centimetres depth of sand, and in the low section on the south side from 15 to 20 centimetres in depth.

As to the sixth question, it is answered in the second.

As to the seventh question, What is the cost of repairing the streets? Never less than 1 milreis (40 cents) per square metre, by contract.

As to the eighth question, Is any assessment imposed upon the adjoining property to make or to repair the streets? None for the municipal coffers, but the State treasury collects a tax of 10 per cent. on the assessed value of the property, not returning anything to the municipal coffers.

Here is the information that I have been directed to give to you.

Health and fraternity,

The GENERAL SUPERINTENDENT.

PORTO ALEGRO, *February* 13, 1891.

RIO GRANDE DO SUL.

REPORT BY CONSUL NEGLEY.

In response to the "street and roadway" circular lately received from the Department. I beg to transmit herewith a report by the city engineer of Pelotas in answer to some questions submitted by me to him on this subject. His answers will cover the ground for the cities of Rio Grande do Sul and Porto Alegre as well as for Pelotas, as the streets in these, the three principal cities of this State, are all made in substantially the same way and at no great difference in cost. The streets of Pelotas are perhaps the best of the three, and are indeed better than in a majority of the cities of the same size in the United States. I speak of the paved streets. As for highways there is so little attempt at improvement it is not worth while to mention them.

CHARLES NEGLEY,
Consul.

UNITED STATES CONSULATE,
Rio Grande do Sul, February 4, 1891.

THE STREETS OF PELOTAS.

[Inclosure in Consul Negley's report.—Translation.]

DEPARTMENT OF THE PUBLIC WORKS OF THE CITY OF PELOTAS,
January 24, 1891.

In response to the questions formulated in the request of citizen consul of the United States resident in the city of Rio Grande, I have the honor of presenting the following points:

(1) What material is used in the construction of your streets?—Answer. As to the first question I answer granite, vegetable earth, and sand.

(2) What does the material cost?—Answer. As the second question, 15 kilos of stone cost 65 reis (.02½ cent), 15 kilos of sand cost 20 reis (.008 cent) and 15 kilos of vegetable earth cost 15 reis (.006 cent), (Exchange at 40 cents to the milreis).

(3) In what manner are the streets constructed?—Answer. As to the third question, by filling in earth or by paving.

(4) Is there any difference between streets paved for light traffic and for heavy traffic? If so, what?—Answer. As to the fourth question there is no difference; they are always made so as to give the resistance necessary for the pressure exerted by vehicles for the transportation of freight.

(5) What is the depth and on what foundation are the streets made?—Answer. As to the fifth, the foundation is of plastic clay, impermeable, merely covered by one light layer of vegetable earth, which varies from 20 centimetres to 50 centimetres at the greatest. As to the method of proceeding: If it is only for filling in earth, there is a mixture made of sand, vegetable earth, rubbish, and clay and given a convex form, placing on the sides stone gutters or drains for carrying off the waters; if for paving an excavation is made of 50 or 60 centimetres, if such should be necessary, and filled with vegetable earth well packed to 30 centimetres, and on the top of that a layer of sand as a foundation for the stones; when the foundation is of clay, on the other hand, there is placed sand and stone, rough hewn, of the following dimensions, 0.08 centimetre on the upper face and 0.12 centimetre in depth at the middle when the stones are irregular.

(6) What does it cost to make the streets, per square metre in the first place?—Answer. As to the sixth this is very variable, because in some streets there is a necessity to fill up more or less, and in others to excavate more or less. It has been the rule to pay for a cubic metre of filling or excavation 450 reis (18 cents) and as much more for transportation. As for the cost of pavement the price at present for a square metre is 1.750 milreis (70 cents), ready for use.

(7) What does it cost to keep the streets in repair?—Answer. As to the seventh, the cost of repairing the paved streets amounts on the average to 3,500 milreis ($1,400).

(8) Is there any assessment imposed upon the adjoining property either to make or repair the streets?—Answer. As to the eighth, yes. The owner of adjoining property is obliged to furnish the stone necessary for the pavement in front of his property as far as the middle of the street; so also he is obliged to make or cause to be made at his own expense the sidewalk along the boundary of his property of the height and width designated by the city council, and if it should happen that he refuses or neglects to furnish the stone necessary he will be punished by a fine of 1.600 milreis (64 cents) for each square metre of pavement in front of his property, which amount will be applied to the benefit of said pavement.

Health and fraternity,

ROMUALDO DE ABREU E SILVA.
Engineer.

COLOMBIA.

BARRANQUILLA.

There are no roadways in this consular district. Aside from river and railway transportation every thing is carried upon the backs of mules.

The streets of the cities are entirely unimproved. From this view of the subject in this consular district there is nothing upon which a report can be based as requested in said circular.

JOHNSON NICKEUS,
Consul.

UNITED STATES CONSULATE,
Barranquilla, February 23, 1891.

DUTCH GUIANA.

REPORT OF CONSUL WYNDHAM.

The roads in this town are not made, but are the existing shell reef, on either side of which the streets are constructed by houses being built, and these roadways are only repaired by occasionally dumping extra shells where the road is worn away too much.

The buildings on the roadside are not allowed to encroach on the roads, which have to be kept open a certain fixed breadth.

In the districts no roads exist, communication being only by boat on the rivers that intersect the colony and by creeks joining the rivers.

I fear it would be impossible to give any points on road-making from this very primitive colony that would interest the mayor of Boston.

WM. WYNDHAM,
Consul.

UNITED STATES CONSULATE,
Paramaribo, December 22, 1890.

VENEZUELA.

REPORTS BY CONSUL BIRD, OF LA GUAYRA.

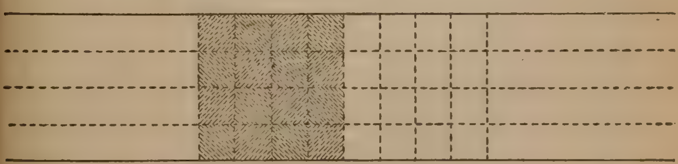
CITY STREETS.

It is assumed from some personal knowledge and from general information that the streets of La Guayra and of Caracas, the capital of Venezuela, are the best in the Republic. Most of these, except in the center of the latter city, are very narrow, so much so that they barely afford passage way for two coaches abreast. They are thus built in order to avoid, in some measure, the tropical heat and glare of the

midday sun, and the overhanging balconies of the upper stories of the houses also contribute to the same effect. Besides, it appears that the currents of fresh air forced through these narrow streets and alleys are much stronger than the feeble breezes that stir through the wider thoroughfares.

In the matter of street paving the Venezuelans have adopted and still maintain the methods of their ancestors, the Spaniards, who settled the country over 300 years ago, and it may be added that these methods have undergone no change, as is observed from much of the old Spanish work still in existence on deserted roads and streets. It is true that some asphalt block pavement has been recently put down in front of the executive mansion in Caracas that presents a pleasing contrast to the old style of pavement, but the improvement seems to have been confined to that particular locality, and there is no prospect of its further extension, and it should be stated that the exorbitant freight rates of the railway from La Guayra to Caracas, precludes the idea of importing paving material. Nothing especially suitable for the purpose is found in the environs of Caracas, and, therefore, such poor material as can be obtained must be made use of. There is an abundance of good brick clay near by, but no facilities for vitrifying the brick, as is practiced in the United States, and hence this material is unavailable.

The street, after being carefully graded, is laid out in long parallel lines, 3 feet apart, into which cobblestones set on edge are planted. Cross lines of stone are then set up at intervals of 3 feet, so that the entire street is laid out in 3-feet squares. These squares are then filled up with diagonal lines of cobblestone set on edge, and, when carefully executed, the paving presents a rather pleasing effect. The plan thus explained is illustrated as follows:



After this paving is completed the entire work is covered with a heavy coating of sharp sand that fills the interstices of the stones and makes the pavement more solid.

Owing, it is presumed to faulty preparation of the subsoil, to the poor quality of stone used and to the careless manner in which it is set up, this pavement can not resist the rolling and pounding of heavy traffic, and, therefore, the business streets of the city are being constantly repaired.

COUNTRY ROADS OR HIGHWAYS.

The northern limit of Venezuela, traversed from east to west by the Cordilleras and Parima mountain ranges, is very rugged and broken for a distance of 70 miles south of the Caribbean seacoast, and hence the construction of highways over stupendous precipices, through almost impassable gorges, and around lofty mountain summits is a work that requires engineering skill and considerable outlay of capital. These prerequisites have never been contributed by the Government of Venezuela; for, if we may except the short coach road from La Guayra to Caracas and the few roads from Caracas to the outlying towns and villages near by, there are no roads in this part of the country that can be properly designated as such. Even the best of them are mere dirt roads kept up in a primitive way; and if, as in the United States, a prolonged rainy season should occur, they would soon become impassable. The road from La Guayra to Caracas above alluded to, although well laid out over great natural obstructions, is very badly kept, and transit over it becomes, at times, difficult and dangerous. The roads, so called, south of Caracas, leading into the interior of the country, are, generally speaking, miserable bridle paths, over which long trains of donkeys transport produce to and merchandise from the city of Caracas. Indeed it may be confidently stated that there is not a 5-mile stretch of third-grade roadway in this consular district.

The old Spanish road from La Guayra to Caracas, about 12 miles in length, now long abandoned, is a curious and interesting relic of the old colonial times, and suggests the idea that perhaps the aborigines of this country had in the Spaniards quite as severe taskmasters as those that weighed the straw and taled the brick for the patient and oppressed Hebrew. All of this wide highway, except some short stretches of level land on the mountain top and along its side, has been well paved in the style now used in the city of Caracas, and much of it, so well and carefully done, is still in a good state. The scenery along the line of this old way is exceptionally fine, and the Spanish cavalier upon arriving at the top of the mountain, and viewing the beautiful valley and city of Caracas at his feet, must have felt quite as contented as the famous Hebrew that gazed westward across the Jordan upon the country reserved for his people.

From the foregoing statement it must appear that none but the most primitive methods are employed in making and maintaining public roads. All the details of the work are of the simplest kind, and the execution by common laborers poorly paid is very inexpensive. The opening and improving of public roads and highways is under the direction of the General Government, but new roads are rarely or never thought of, and others are only improved when they become impassable. Such a system, it may well be imagined, contributes little or nothing to the value of lands contiguous to these roads and constitutes a serious

barrier to profitable commerce between Caracas and the interior country.

WINFIELD S. BIRD,
Consul.

UNITED STATES CONSULATE,
La Guayra, December 10, 1890.

BRITISH WEST INDIES.

ANTIGUA.

REPORT BY CONSUL BRADFORD.

There are at present, in Antigua, about 10 miles of streets and 140 of roadways, kept in thorough repair at an annual cost of about $15,000, besides which there is an annual grant of $1,200 for mason work and repairs to bridges. Construction and maintenance are both carried on under the provisions of the road act of 1880,* which is very comprehensive, and has, I am given to understand, worked to the satisfaction of both the citizens and the government.

Under the act the highways are divided into five classes: Class I embraces the 10 miles of streets; Classes II, III, IV, and V are all country and suburban roads. The division was made (1) with reference to greater or less difficulty, in places, or obtaining suitable stone; (2) to the amount of traffic likely to pass over a road; and (3) to the greater or less liablity to drainage by heavy rains. It has been found to simplify very much the system of construction and repair, and has worked well during the past 10 years.

Convict labor is permitted, within a radius of 1 mile from St. John's, on six of the most frequented roads and on that leading to the naval station at English Harbor.

CITY STREETS.

Construction.—The streets of St. John's are constructed and kept in repair by the superintendent of public works and the cost defrayed out of the ordinary taxes, as in our own cities. The method of construction is as follows:

The surface earth is carefully excavated to a depth of at least 12 inches and leveled. This street bed is then covered with 4 inches of "grit"† or similar durable material, and with this layer the contour of the road way is formed, as to the height of the crown of the street and its slope and level. In this material no stone over 1½ inches in diameter is permitted. Over the grit an even stratum of broken stone is laid to a depth of 8 inches. This is called "metaling." The whole is then covered with grit and sand, as a binding material, spread

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* Legislative council, Leward Isles, No. 7, July, 1880.
† Stone broken or mashed very fine.

to a depth of three-quarters of an inch. A curb, composed of stone blocks 10 by 14 inches in diameter and 8 inches thick, strongly cemented together, separates this roadway from the sidewalk, and at its base a wide gutter is formed. The curb is composed of the stone found on the island—usually crystalline limestone—and the gutter is either of the same stone, of brick, or of large square tiles.

The sidewalks of the city streets were intended to be of a width of 8 feet, but the citizens have in so many instances encroached upon them by verandas, flights of steps, etc., that it may be said there are no sidewalks in St. John's. Some buildings project so far as to leave barely 2 feet width between the curb and the front of the houses. It is understood, however, that this will be corrected. What sidewalks there are are not paved, except in a few instances under the porticos of prominent business houses where stone flags are laid. Drain pipes, 12 inches in diameter, and culverts are laid throughout the city, so that the streets are rarely flooded, even in the heaviest rains.

The height of the crown of the causeway varies according to the profile of the surface, in some streets being about 6 inches above the gutter level and in others a foot, or even more.

When the construction of a street has been thus completed it requires at first little attention beyond the smoothing down of wheel tracks and the filling up, with broken stone, of ruts or hollows caused by vehicles constantly following each other in one track. This filling up is continued until the roadway has become thoroughly consolidated, and it must be remembered that this desirable consummation can be obtained only through the travel over the street and this constant supervision, for there are no steam-rollers and no hand-rollers of sufficient size in the islands; but once the roadway is finally completed its endurance is very great. It will need absolutely no repairs for a very long time and then but slight ones.

Such streets as I have just described can be constructed here for only 9 cents a square yard, and kept in repair with the insignificant outlay of from $100 to $150 a linear mile. They are solid and firm—never dusty in dry weather or muddy in wet—and are, except where out of repair, so easy to the pedestrian that the reason for the neglect of the sidewalks is at once apparent.

Repairs.—The maintenance of the street-ways in St. John's is part of the duty of the superintendent of public works, who likewise designs, constructs, and repairs all bridges, culverts, etc. Repairs are made by day labor, and consist of filling up holes, ruts, or other defective places in the "macadam." This is done by first breaking up the surface to a sufficient depth over and for some distance around the site of the defect, then removing this old surface and spreading over the place thus uncovered a layer of broken stone, averaging about 2 inches in diameter. This, again, is covered with coarse sand and grit as a binding layer, and the street is thrown open to traffic. Where repairs are

required throughout the whole width of a street the metaling with hard stone is done only in the middle—say to a distance of about 6 feet on each side of the crown—while at the sides and up to the edge of the gutter only light material, broken up fine, is used, and for this purpose the common "mud stone" of the island is most in vogue, covered with a thick layer of sand and grit. The reason of this is obvious, the traffic in the middle of the street being ten times as great as that at the sides, which last is almost altogether pedestrian.

Where narrow streets or alleys are to be repaired it is usual to matel them from gutter to gutter.

The street in front of this consulate has just been repaired in this manner, and, although completed only a week ago, is now in excellent condition for travel of all sorts.

The cost of these repairs is about from $100 to $150 per mile annually. Taking it at the larger cost, it amounts to a little less than 3 cents per square yard.

COUNTRY ROADS OR HIGHWAYS.

As mentioned in the introduction to this report, these roads are also macadamized, with a few exceptions. The stones used in metaling are such as are found in the vicinity of the road being constructed, and are chiefly hard crystalline limestone, flint, and obsidian, to which may be added, for volcanic districts, trap rock. The stone for the roadbed is broken up very fine and mixed with grit. Flint, obsidian, or limestone is broken to a size that will pass through a 2-inch ring, but volcanic rock is crushed still smaller, say about an inch and a quarter.

Construction.—In construction the first thing after the location and leveling of the proposed road by the surveyor is to pare off all of the surface mold. Then the roadbed must be made of mashed stone and grit (or like enduring material), taking especial care to see that no stone larger than 2 inches in diameter is found in this layer. The shape of the road from crown to side trench (ditch) is formed with this layer of grit and stone. Natural hollows, where not too large, are also filled up with it to the required level of the road. After this is completed the road is "metaled" to an uniform depth of at least 6 inches, and this final stratum of stone is covered half an inch or more with grit and, occasionally, sand and gravel as a binder. Side trenches or ditches are dug, and, in particular cases, where heavy washings from the winter rains may be anticipated, these ditches are faced with masonry. The cost of the mason work is, however, as before mentioned, defrayed from the special fund of $1,200 per annum allowed for masonry and bridge repairs. The building of the walls, culverts, bridges, etc., is done by the government and is not charged to the road fund.

Thus built, these roads cost, exclusive of bridges, etc., $1,260 to $1,270 per linear mile.

The stone for the foundation and metaling can be carted from a

reasonable distance, say from one-half to three-fourths of a mile, broken up and spread upon the road at a cost of from 8 cents to 12 cents a barrel for limestone, and for from 12 to 16 cents for flints and harder kinds of rock. These latter, especially volcanic stones, require to be broken to a smaller size than the limestone, say 1½ inches in diameter at most. The barrel used in measuring the broken stone is an ordinary flour barrel, without top or bottom, and contains about 4 bushels of stones or 5 cubic feet.

It is proposed now to use in future construction or repairs the petrified mud, which is here called "mud stone," as a binding material for roads where there is much traffic, and this proposition is meeting with much favor, especially in localities where flints are used in metaling, and will, in all probability, be adopted. The advantages of the mud stone are that it forms with the hard stones a more even surface, being not easily ground or pushed out from between the flints, and that it takes less watching when newly laid, soon settling down with the hard stones of the road into a smooth, compact, and consolidated mass.

Repairs.—These are made by the government, except where the roads pass through an estate or between two estates. In the latter cases, by the road act of 1880, the repairs must be made by the proprietor or occupant of the estate (see sec. 5 of the act) or abutting estates, and for such repairs the government, on proper representation, remunerates the proprietor or occupant according to the schedule of rates given below.

Should any proprietor or occupant neglect to repair the road where it passes through his estate he is first notified officially and in writing of such neglect, and should he, after the formal service of such notice, allow 10 legal days to pass without commencing such repairs, they shall at once be effected by the superintendent of public works, and the cost, together with a fine of 40 shillings or $9.73, shall be charged to the estate. This cost and fine are recoverable before a discrict magistrate like any other simple debt. Where the road is greatly damaged, as by freshets or heavy rains, the proprietor is allowed 21 days to complete the repairs, but he must, in the mean time, make it passable for vehicles.

Schedule of rates at which payments are made for repairs on country roads.

Class.	Repairs.	
	Allotment per mile.	Annual amount.
*I.	First 4 years	$121.00
	After 4 years	170.31
II.	First 6 years	77.86
	After 6 years	97.33
III.	First 8 years	58.40
	After 8 years	67.07
IV.	No longevity allowance	29.20

* This is Class II of the general classification of the streets and roads of the island; and so with the other three. Class I, in the general arrangement or division, is formed by city streets.

There was formerly an extra allowance for metaling, but that repair is now done by the superintendent of public works. It must be remarked, in this connection, that the roads under repair are rarely if ever metaled to any considerable length unless there is great damage by floods. As a rule all the repairs required besides trenching are the filling up of ruts and hollows as they appear. If proper attention is paid to this the roads will rarely require extensive metaling. In repairing precisely the same method of procedure is followed as in the repairs of streets (see pp. 4–5), with the single exception that there is not so much excavation, nor is it at all necessary. Ruts or holes are simply filled up with broken stone of from 1½ to 2 inches in diameter, and a binder spread over all. In cases of severe washing it is usual to take counsel as to the proper repairs with the superintendent of public works.

General Remarks on Roadways.—It is to be remembered in considering the depth of excavation and the material used in these macadamized roads that the traffic over them is what would be generally recognized as light, the heaviest weights which ordinarily pass over them being "estate carts," drawn by two or four mules and loaded each with 1 or 2 hogsheads of sugar weighing a ton apiece. Yet heavy boilers weighing from 8 to 10 tons and steam plows are occasionally carted over them without doing any damage, especially if the roads are dry and unwashed.

In considering also (2) the question of the low rate of cost in making and maintaining these roads as compared with the cost of properly macadamized roads in the United States it must be remembered that the wages of the laborers in the Leeward Islands averages from 20 to 28 cents a day, as opposed to $1.50 with us. As an offset to this, however, the laborers in the West Indies do but a small day's work as compared with that accomplished by a laborer in our own streets and high ways, a fact which renders the contrast less striking. It may be safely estimated that a day's labor in these islands is equal to about half a day's labor in the temperate zone, so that taking into the account the difference in cost of living, the actual wages of labor in making and maintaining the road in the tropics would be about one-third of what it should be in the United States or Canada.

GENERAL EFFECT OF IMPROVED HIGHWAYS.

That easy and quick transportation of land products from the place of production to the port of shipment reduces the cost of said products delivered at the port goes without saying. What the actual amount of saving in money values is I do not know and have no means of learning. The planters keep no record of such saving. The simple fact, however, that whereas sugar in former years (previous to the adoption of the act of 1880), was worth, delivered for shipment, $45 a hogshead and is now delivered at $40 speaks for itself. Nor can the whole of

this reduction, nor even a large part of it, be traced to the abolition of the export duty, which was only 97 cents a hogshead. That duty was only abolished in 1888; and, besides, the sugar planters assert that they never received any benefit whatever from the abolition of the duty, the amount of the reduction having been absorbed by the "middle-men." And it does not require a profound mathmetician to determine the result in reduction of price arising from quick and easy transportation to market as compared with the loss of time and labor and the injury to the stock and vehicles by bad, miry, and broken roads.

In conclusion I would say that, notwithstanding their small relative cost, I have never seen better roads than those in this island, and seldom as good. They are smooth and even; and although I write in the middle of the rainy season, I have never seen enough mud on them to impede in the slightest degree traffic either light or heavy. The lightest and most delicately made sulkies and road wagons travel over them daily without the slightest injury; and (which is of greater importance to the commerce of the island) the time occupied in transportation of sugar and molasses during the rainy season to the port of shipment is diminished by at least one-half.

JOHN S. BRADFORD,
Consul.

UNITED STATES CONSULATE,
Antigua, January 14, 1891.

RECAPITULATION.

Miles of streets (approximate)	10
Miles of roads	140
Annual cost of construction of streets:	
Per linear mile	\$1,537.880
Per square yard	\$0.093
Annual cost of repairs of streets:	
Per linear mile (average)	\$150.000
Per square yard (average)	\$0.026
Annual cost of construction of roads:	
Per linear mile	\$1,267.200
Per square yard	\$0.080
Annual cost of repairs of roads, variable according to class:	
Per linear mile	\$29.20 to \$121.000
Per square yard	\$0.005 to \$0.020
Wages of laborers per diem	\$0.20 to \$0.280
Cost of material per cubic foot	\$0.02 to \$0.03½

System of construction and repair, Macadam.

REPORT OF THE COMMISSION ON PUBLIC ROADS, ANTIGUA.

To his excellency Sir WILLIAM FREDERICK HAYNES-SMITH, K. C. M. G., Etc.:

(1) The commission appointed by your excellency to inquire into the whole question of the maintenance of the public roads in Antigua held its first meeting on the 20th January last.

(2) With the object of gathering the views and wishes of as many as possible of those specially interested in the question before the commission, the island was divided into districts, and the leading planters, or their representatives, in each district were invited to attend before the commission.

(3) Of the thirty so invited eleven were good enough to attend and to give the commission the advantage of their coöperation and assistance.

(4) The information elicited from these gentlemen will be found in detail in the minutes of the proceedings appended hereto.

(5) The labor of the commission was much facilitated by the unanimity of opinion which prevailed among the witnesses with regard to the main principles of the present road act, which was thought to have worked admirably, and to require but little if any amendment.

(6) The system of paying the estates to keep the roads in repair was unanimously approved, and it was the general opinion that no alteration in the rates of remuneration was necessary, inasmuch as although the amount paid for repairs to one portion of a road might not cover the cost of such repair, that paid for repairs to another portion would be in excess of the cost, and that an average was thus arrived at which enabled the estates, as a rule, to keep the roads in repair without either loss or profit.

(7) A proposal for repairing all roads under a system of contracts met with no support, although it was thought that where the surveyor of works has roads to repair tenders might with advantage be called for in the majority of cases, and in this latter suggestion the commission concurs.

(8) There was a diversity of opinion as to the amount of supervision that ought to be given to the roads, and it was suggested that the island should be divided into two or more districts with an overseer for each, but after carefully weighing the whole of the evidence the commission is of opinion that the supervision now provided should be sufficient; that on the whole it has proved so, and that no immediate necessity exists for any increase of staff.

(9) The drains and gutters running across the roads were objected to as they are now made, and it was the general opinion that strong culverts should be made where possible, and where not possible simple and inexpensive bridges should be erected.

(10) The use of 12-inch pipes was suggested and the commission consider that much might be done to make the roads more level and easy to drive over if such pipes were used, and if the estates were required by law to keep the culverts and pipes free from obstruction and choking.

(11) It was also suggested that where estates required to make drains across roads pipes for this purpose should be supplied at cost price by the government, and to this the commission can see no objection.

(12) Paying the estates for keeping in repair the cross-gutters, culverts, bridges, etc., adjoining their property on the same plan as payment is made for repairs to the roads was suggested, and although the commission considers that the surveyor of works should, subject to the approval of the governor in each case, be authorized to make arrangements for doing this where practicable, it is unable to recommend the suggestion for general adoption in the sense in which it was put forward in consequence of the difficulty there would be experienced in arriving at a proper settlement of the amounts payable.

(13) The making of mould traps too near the public roads was pointed out as not only the case of much avoidable expense in keeping the side drains open, but as a source of danger to persons riding or driving, and the commission suggests that the making of mould traps anywhere within 10 feet of the trench running along the public road should be forbidden and made a punishable offense.

(14) With regard to the material to be used upon the roads for their repair, it was pointed out that although provision is made in the road act (No. 7 of 1880) for the use of metal no provision is made for the use of other material, and although the com-

mission considers the provision for metaling very necessary and one which should remain in force, it is of opinion that where the use of metal is not necessary the surveyor of works should have power to order the use of some other suitable material.

(15) The word "metal" has not been defined in the act, but has been taken to signify "broken stone."

(16) The stones put upon the roads were considered to be, in many cases, too big, and the use of flint was taken exception to. As to the size of the stones this is a matter which should, the commission thinks, be regulatid by the surveyor of works, and with regard to flint the commission can see no objection to its use provided that when used it is covered with some suitable binding material. The commission would suggest that a provision to this effect be made.

(17) In many of the roads and side drains a rocky surface presents itself, and the commission suggests that where practicable and desirable this surface should be blasted or otherwise disposed of, and that when the roads so treated are repairable by estates they should be put in order before being handed over again to the estate.

(18) A suggestion made by one of the members of the commission (Mr. Oliver Nugent) that a system of tramways should be arranged along the main roads of the island appeared to meet with universal approbation, and the commission would suggest that a few gentlemen of the island be selected to consider and report upon the practicability and cost of carrying out such a scheme.

(19) The proposed abolition of fourth-class roads was not generally approved, and the commission is of opinion that as these roads are better than no roads they certainly should be retained on the schedule.

Their removal generally to the third-class could not be entertained on the score of expense.

(20) There was no general complaint as to the manner in which the roads had been measured, and it was not ascertained that any required remeasurement.

(21) Some of the roads, it was thought, should be widened to the width required by the act, and the commission considers this should be gradually effected along the most frequented routes.

(22) It was suggested that estates in receipt of grants for the maintenance of roads should be compelled to keep and render accounts of their expenditure ; the commissioners, however, do not see that these accounts could be properly audited, or that in the absence of an audit any material advantage would be derived from an adoption of the suggestion.

(23) The posts, defining the boundaries of the various estates, are looked upon as of distinct advantage, and their upkeep and renewal where and when necessary is recommended.

(24) The commission did not consider it came within its province to entertain applications for the removal of roads from one schedule to another, but rather that such applications should follow the usual course and be dealt with, each upon its own merits, as heretofore. The condition of the road from Elm's stream through Gray's and Wickham's was however brought prominently to notice, and the commission recommends that, so far as this road runs through the swamp, it should be remade and raised some feet above its present level by the Government, the estate being required to keep it in repair thereafter.

The road from Fry's to Bodkins should be a first-class road throughout; at present part is second class and part first. The commission makes this recommendation in consequence of the extraordinary cost required to maintain the road in a proper state of repair. The Gilberts gap to Lyons road is recommended for removal to the second class.

The commission would ask that attention may be given at an early date to Delaps and Bath Lodge streams, which might, it is thought, be dealt with under "The water-course act of 1889."

(25) A proposal to create a special class for roads which required an extraordinary

expenditure to maintain was not entertained by the commission, as it was thought the creation of such a class would to some extent be prejudicial to the proper working of the existing road act under which losses on one part of a road are made up by gains on another part, and that it would be better to leave any case in which hardship is shown to exist to be dealt with specially by the legislature.

(26) It was thought prior to the meeting of the commission that some amount of dissatisfaction existed with regard to the working of the present road act, but this has not been shown to be the case; in fact, there would appear to be strong objection to any alteration of its main provisions or principles.

FRED. EVANS, *Chairman.*
JAS. MAGINLEY.
J. FREELAND FOOTE.
ARTHUR W. HOLMES á COURT.
OLIVER NUGENT, JR.
J. SUTHERLAND.
V. GUFFROY.

ST. JOHN'S, ANTIGUA, *June* 16, 1890.

BAHAMAS.

REPORT BY CONSUL M'LAIN, OF NASSAU.

I regret to say that the conditions existing here for the making of roads and streets are so essentially different from anything in our own country that, in my opinion, nothing that I could mention would be of the slightest value to our street builders and road makers.

The Bahama Islands are composed of coralline limestone, and the surface of this natural rock forms the street or roadway. There is no depth of soil, the rock itself being often fully exposed to view. All that is done to construct a street or roadway is to remove such sparse brush or chaparal as may be growing thereon (the rock itself being so porous and full of crevices and fertilizing elements as to sustain considerable vegetable growth with little, if any, soil), smooth down any sharp projections of rock, and fill up depressions with small pieces of the broken stone. As a result you have a reasonably smooth roadway of solid stone, which will meet all the requirements of the people.

In the outlying islands of the colony there are comparatively few roads, and such as exist are little more than pathways cut through the bush, wide enough to permit the passage of a single two-wheeled farm cart, which is about the only vehicle in use. The fact that the islands are generally of considerable length and narrow width renders roadways less necessary, the people owning their boats and passing easily from point to point along the shore.

In the island of New Providence, whereon is situated the capital, the city of Nassau, a town of about 12,000 inhabitants, more attention is paid to streets and roadways, but here, as elsewhere, the solid rock forms the street or road.

The original cost of the streets is not great as there are no difficult

problems of grade, sewerage, or engineering, and the cheapest and rudest form of labor is used in their construction. There are few streams or ravines requiring culverts or bridges.

The limestone rock is comparatively soft, and, in consequence thereof frequent repairs of streets are needed in the city proper. These consist of filling up holes and ruts, and renewing gutters which run along the sides of the streets, emptying into lateral deep drains which, in turn, are discharged into the harbor, a strong tide carrying everything out to sea. In making repairs the material used is the same quality of limestone, broken into small pieces, wetted, and packed smooth by heavy iron rollers, when it rapidly becomes as solid as the best kind of cement. The streets thus made are not particularly hard, but they answer all demands, since nothing known as heavy traffic ever passes over them. The vehicles in use are light carriages, farm carts, and common drays, seldom drawn by more than a single horse each.

The annual expenditure for keeping the streets and roadways of this island in repair is not great, a yearly appropriation of about $7,000 being made for that purpose, by the legislature. There are no road or street taxes collected, as such, in this colony; but all expenses are paid from the general fund, and disbursed by the board of public works. Some work is done upon the streets from time to time by prisoners working in chain gangs, but the value thereof is not very great.

No obstruction to uninterrupted travel ever arises from the wet or muddy condition of streets or roads in the Bahamas, since the soil, where any exists, is too thin and sandy to retain water, and the bedrock is so porous as to absorb within a few hours the heaviest tropical downpour of rain.

The extent of streets in Nassau is about the same as is found in towns of the same population in the United States; whilst the total length of the roadways, under public control, on the island of New Providence, outside of this city and its immediate suburbs, I should estimate as not to exceed 45 or 50 miles.

The island itself is about 20 miles in length, with an average width of perhaps 5 miles. Two years ago there was less than one-third of the island under cultivation and hence no great need for country roads; but now large tracts are being planted in sisal, for the production of fiber, and new roads are being projected and will shortly be built in all parts of the interior. They will all be of the same general character as those now in existence, and will be easily and cheaply made.

THOS. J. MCLAIN, JR.,
Consul.

UNITED STATES CONSULATE,
Nassau, N. P. November 28, 1890.

BERMUDA.

REPORT BY CONSUL BECKWITH, OF HAMILTON.

CITY STREETS.

The streets and roads in Bermuda are made and maintained chiefly from the native coral rock of which the islands are composed. The method of making the streets is to cut through the solid rock forming the hills or elevations, making the sides of the cuttings perfectly perpendicular, and cutting down until a suitable grade is established, which is generally made as near the sea level as practicable. This cutting is done by means of large saws, similar to an American cross-cut saw, and the rock being again sawed into smaller blocks it is removed either by blasting or by cutting out with a large iron chisel. This chisel has a length of about 12 feet and a blade about 4 inches in width. These chisels weigh from 12 to 15 pounds and their weight helps greatly in cutting, as they are used after the manner of a "digger" for post holes. The rock is very soft and porous, but hardens on exposure to the weather. The rock removed from these cuts is used in filling in the depressions and hollows until the road is brought up to grade. In certain parts of the islands a sort of limestone exists of harder substance than coral. This limestone the government causes to be collected, taken to the different jails, and there broken up by prisoners, both civil and military, into small pieces about three-quarters of an inch to 1½ inches in diameter. These broken pieces are called "jail nuts." This broken stone is now bought from the government by contractors and spread over the graded road to a depth of 3 or 4 inches. Then a top dressing of small coral rock is put on, which soon crumbles under wear and forms with the limestone an excellent macadam, very smooth, very clean, and very durable. It so readily absorbs the water that mud is unknown here. To repair this kind of road it is only necessary to pick it over to the depth of 2 or 3 inches and add a little broken limestone where there is any great washout or sinking.

The above is the only system of road-making known here and the details of construction are in every case the same as above. The expense of making and maintaining the city streets is borne by the corporation of the town, which hires the necessary men, teams, and foremen or overseers. The expense of watering and sweeping the streets is also borne by the corporation and performed in the same manner.

COUNTRY ROADS OR HIGHWAYS.

The method of making the country roads or highways is exactly the same as that used for city streets, *i. e.*, to cut through the rock forming the hills and elevations with a saw, saw the coral into smaller blocks, and remove the débris by blasting or use of the chisel. This loose rock

is then spread over the hollows and depressions until a suitable grade is established, and a low grade is chiefly used. The same limestone used on the streets is spread on these roads in the same way, and the top dressing of coral on that. These roads are repaired the same as the streets, *i. e.*, by picking them over and adding broken limestone. The expenses for all kinds of road building are chiefly for labor and the cost of the broken stone. A laborer receives $1 per diem, a man with horse and cart $2.50, and the limestone costs about from $1.25 to $1.50 per ton delivered at jail. The expenses of building and maintaining all country roads and public highways, except city streets, are borne by the colonial government, and the work is let out to contractors by bids. In many cases in this class of roads it is impossible to cut directly through a hill or elevation, and the road is then carried around it with the easiest grade practicable, cutting into the sides of the hill where possible to shorten the curves.

The effect of good public roads has been here to greatly increase the value of land, especially that designed for residences, and at present two roads are in process of construction across a marsh hitherto unused, which will probably cause the marsh to be filled up and used as farming land. There are also roads here called military roads, chiefly lying about the British fortifications and camps or leading to them. These roads are built and maintained by the military, the labor being performed by the soldiers. These roads are marked by large mile-stones set up by government surveyors. There is a law in force here tha "any road remaining open for 21 consecutive years becomes a public road and passes under the control of the colony." Therefore to retain the right to control these military roads the British government causes them to be closed for one day in each and every year. This law does not apply to the public highways or city streets.

HENRY W. BECKWITH,
Consul.

UNITED STATES CONSULATE,
Hamilton, Bermuda, December 24, 1890.

JAMAICA.

REPORT BY CONSUL ESTES.

The Macadam system of road-building is used altogether on the streets and "government roads," as the main highways are called, and on the best of the byroads in the plains, but the mountain "parochial roads," usually little better than mere trails or bridle paths, are left to the tender mercies of heavy rains and unskilled labor to a great extent and are far from worthy of any extended notice in this report.

The same system, however, that leads to cut-up and make dusty

streets during the dry season and to flowing rivulets of mud and water in the wet season, under the heavy hauling in some parts of Kingston, yields most excellent driving roads in the outskirts of the city and main highways, far above the average in the western hemisphere, in the country.

The stage routes throughout Jamaica, though used by the peasantry to an unusual degree, are in many places quite equal to many of the trotting tracks of the United States in smoothness of surface and elasticity.

The formation or basis of Jamaica is of igneous rocks, overlying which are several distinct formations, principal among which are the white and yellow limestone or "rotten marls," as they are sometimes called here. These very brittle formations lend themselves readily to road construction, and it is due to their presence near at hand throughout most of the island, combined with the very low scale of wages, that Jamaica is possessed of so excellent a highway.

All the stone used, which is broken to about the standard size of "small stove" coal in the United States, is so reduced by women, who break it piece by piece with a steel hammer, sitting with a pile of boulders in front of them and often working for hours without moving from one spot. For this severe labor they usually are paid, by task-work schedule, about 18 to 24 cents per day. This material is then taken, usually in trays carried on the heads of women and girls, to the road and sprinkled on at such places as the road overseer points out. Some of these women become quite expert and can be left for several days to go on with this work undirected. Here also the same small wages hold.

Steam rollers, road scrapers, road plows, and all other forms of road machinery are unknown here, the shovel, common grubbing hoe, and the machette or cutlass are the only implements used in the grading, surfacing, and cleaning of the roads.

When the broken stone is put on the roads it is left in that condition, the frequent and almost constant traffic over much of their extent sufficing to soon bring the whole to an even surface of a hard but elastic and fine consistency.

Water courses, where small, are for the most part conveyed beneath the roadways in concrete pipes the sections of which are here made of this same material mixed with Portland cement; this more skilled work, usually done by men with women assistants, can be obtained for an average of 50 cents per day.

In this very primitive fashion the inhabitants of Jamaica are enabled to enjoy roads of over 500 miles in extent, circumscribing and intersecting the island, which will compare favorably with the Pullman road of Chicago and the system around the larger Eastern cities of the United States.

To the various parishes, corresponding closely to our counties in the United States, is allotted the care of all such roads as are not of sufficient importance to make them subjects for the care of the colonial government; the main highways, however, are now under the care of the director of public works, who, with the assistance of five district engineers, a government surveyor, and four superintendents of roads, is directly responsible to the Government for their condition.

While the expenditures for main roads are borne on the annual estimates, and are chargeable to the general revenues of the colony, still there is a system of taxes which is ingenious and which contributes in no small degree to swell these revenues.

This system consists of taxing all such articles or animals as in any way contribute to the wear and tear of the roads. Some of these items are as follows:

	£	s.	d.	
Each head of horse kind used on roads	0	11	0	=$2.67
Each head of ass kind used on roads	0	3	0	= .73
Each horse, ass, or other stock not used on roads	0	1	0	= .24
Each wheel of a carriage	0	15	0	= 3.65
Each wheel of a cart	0	6	0	= 1.46
Each wheel of a hackney carriage	1	0	0	= 4.86

The report of the director of public works for 1876 to 1888, inclusive, shows that the average annual expenditure for repairs and maintenance was but $165 per mile. During that time the new works, consisting mainly of new bridges and some entirely new roads, have been about $230,000; this has been for a main road system extending throughout a mountainous island, which is quite adequate to meet the needs of about 800,000 inhabitants in an area of 4,193 square miles, of which only 646 square miles are flat or plain land.

When it is remembered that the extremes of heavy flood rains and of hurricanes have to be contended with, it is generally considered that this is a remarkable showing.

The dry, parched, and rocky bed of a strean on one day may be the course of a roaring torrent, carrying everything before it, on the next day; the clean roadbed of one moment may be strewn with the débris of the mountain hurricane but a few moments after.

While these are not frequent causes of extra outlay, they did call for an increase of about 25 per cent. in expenditure in 1880 and 1886.

W. R. ESTES,
Consul.

UNITED STATES CONSULATE,
Kingston, Jamaica, December 9, 1890.

TRINIDAD.

PRINTED REPORT TRANSMITTED BY CONSUL PIERCE FEBRUARY 6, 1891.

Practical suggestions for road making by Mr. Devenish, town superintendent of port of Spain.

Before proceeding with the repairs of the roads, an important point should be first determined, viz, the legal breadths of the roads; such breadths to be equally measured from the center of the roadway towards the adjoining fields, except in cases where a road runs along precipices, hills, cliffs, landslips, and river or sea side, etc.

For any road used for the cartage of produce, or first class road, 40 feet should be allowed for the out-and-out width. Of these 40 feet, 30 to be between the inner sides of the trenches.

The width of the other roads of minor importance should be determined by the nature of the locality through which they may pass.

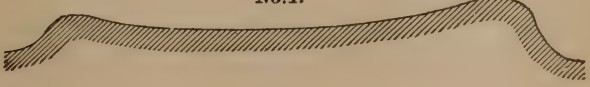
The proper width having been ascertained and determined, a space of at least 4 feet on each side of the road should be kept free from plantations, bush, or live fences, so as to allow to the road the full benefit of wind and sunshine.

Previous to attempting any metaling, or, in fact, any general repairs on a road, the greatest attention must be paid to its proper cross-sections and drainage.

The roadway should be carefully and evenly sloped from the center to the trenches at an inclination of from 3 to 4 inches in every 10 feet, as local circumstances may direct.

The general shape of the old roads which are to be brought to a true cross-section is as follows, viz:

No. 1.



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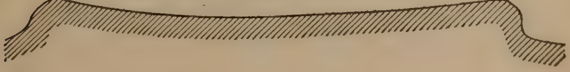

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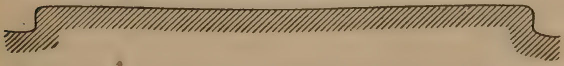

The most economical, and, in fact, often the only, mode of correcting the vicious shape of such roads when they have never been coated is—

In No. 1, by raising the lower side and forming the section with the cuttings from the higher one, thus:

No. 1.

And in Nos 2 and 3, by filling up and raising the center with the earth taken from the sloping of the sides and digging out of the drains, thus:

No. 2.

No. 3.

The earth thus thrown on the road should never be allowed to lie in large clods, but should be well broken and rammed down as much as possible.

It sometimes happens in case No. 1, when the road has been long metaled, that there is on the higher side almost enough metal, if not to correct entirely the section, at least to help much in doing so.

In no case, however, should a graveled road be thus brought to a true convexity with mere earth thrown on the coated surface.

In graveling roads the proper shape must then be attained by throwing the cuttings off the road and by gradually raising the lower side by repeated layers of gravel or metal.

In very low and soft places, when brush wood is at hand, the road is very advantageously raised by laying fascines or even logs of wood transversely and covering the same with at least 12 or 15 inches of earth.

The all-important operation of drainage requires next the greatest attention on the part of those in charge of the roads.

It must generally be carried on simultaneously with the forming of the road, as the earth taken from the side channels is often the principal means of raising the bed of the road and of shaping it.

From actual experience I am of opinion that the edge of the angle of the drains with the roadway, owing to the very careless driving on our roads, should be sloped off thus , so as not to be injured by the wheels of vehicles coming too near the drains.

When this angle is not sloped off the inner side of the drains in most of our roads is constantly destroyed, and the earth thereof tumbling into the trenches soon fills them up.

On roads where I have thus sloped the drain-side nearly 5 years ago the trenches and sides of the roads are still almost as perfectly shaped as when first made, and the expense of cleaning the drains has been infinitely less than when the angle is retained.

The outer side of the trenches should be carefully sloped according to the nature of the soil.

In the clayey soil of the Naparimas the slope should never be under an angle of 45°, that is, 1 foot horizontal to 1 foot perpendicular for cuttings under 2 or 3 feet, but for a greater height, to prevent landslips, it should never be less than an angle of 30°, or $1\frac{3}{4}$ feet horizontal to 1 perpendicular.

In cuttings, such as in the light sandy Tacarigua soil, a far steeper slope will do, such as one-half foot, and even one-fourth, to 1 foot.

The depths of the side channels must of course depend a good deal on local conditions, but great attention should be paid not to make them unnecessarily deep, and more particularly not to give them too great a longitudinal inclination.

This is a fault often committed in the side trenches of many of our roads, principally along hill slopes, where, on the contrary, it should be most carefully avoided.

Too much inclination causes a strong current and a rush of water that soon undermines and destroys the sides of the drains and very materially damages the road.

On hilly roads, therefore, the drains ought to be dug deeper at the highest point and their depths gradually lessened in going downward, so as to correct in some measure the natural declivity of the ground.

When the road is very steep the channels are sometimes advantageously cut like steps at convenient distances in order to give them a more gentle inclination. But whenever this is done stones must be carefully hand-laid on a few feet immediately under the fall of the water to prevent it from digging and destroying the bottom of the lower drain.

Whenever a road runs along the side of a hill the greatest care must be taken to prevent the hill water from overflowing the upper drain and running across the surface of the road.

In such cases cross underdrains made of hard wood or masonry must be established at conveniently short distances all along the hillside and their lower end carried always at least 5 or 6 feet beyond the breadth of the road.

The inlet or upper ends of such cross drains should always be protected by either hardwood posts and planks or by small wing walls, and great care taken that they are never choked with weeds, trash, or any rubbish carried by the water.

An inclination of 1 inch in 10 feet is enough for such cross drains. Their diameter must be regulated by the locality, but in general drains 2 feet wide by 18 inches deep will be found large enough.

In covered drains made of hardwood I have found it very advantageous to bore one or two rows auger holes in the top planks and also along the sides, 8 or 9 inches above the bottom. These holes help a good deal in drying up the subsoil all around the cross drains.

Catchwater drains are also often indispensable on the upper side of the slope to catch the hill-water and carry it into the inlets of the cross covered drains, thus preventing too great a rush of water into the upper side channels.

Small but numerous outlets, and in low, level ground larger ones, or main side drains to carry the water from the side channels to the adjoining fields, or into the natural water-courses, when near enough, should be regularly established at moderate distances along a line of road, and always kept well clear and open.

In no case whatever should the proprietors or occupiers of land along the road be allowed to drain their fields into the side channels of the roads. They should be compelled by law to bring such water into a main drain parallel to the road, and which would carry it to some lower points or to some natural water courses.

Whenever springs are met with in a road the place should be dug right down to the very spring, and a deep channel cut thence across the road and filled up with either large broken stone, or logs of wood covered with a foot or 18 inches of earth or road materials, as the case may be.

After a road shall have been well shaped and drained, and in no instance till then,

the surface of the roadway must (when practicable), be coated with the best suited materials at hand.

In this colony, where, owing the very small and inadequate amount of capital available for making and repairing our roads, it is not probable that the most approved system of road-making in the mother country can be carried out, at least for many years to come, it behooves us to see in what manner we can turn our resources or means to the best possible advantage.

If the road to be graveled is an earth road (that is, never coated) or newly shaped road, the surface must first be allowed to be sufficiently rammed down, either by the traffic or with heavy "rammers," until it becomes consolidated enough to receive the gravel or metal.

When this is done the gravel or metal must then be carefully spread on a width of 15 feet, at equal distances from the side channels, first in a layer 4 inches thick throughout.

After this first layer shall have been sufficiently compressed and settled (which will happen in very few days on a road with any traffic), then a second coat of 4 inches again is to be laid over it, and also allowed to settle for a few days, when a third and top course, also 4 inches thick, will be applied to complete the work, thus giving a total depth of 12 inches to the crust of the road, or 55½, say 56, cubic yards, of materials per every 100 feet of road in length.

During this process laborers should be employed to rake the several courses as evenly as possible to prevent the formation of any ruts or holes and spreading of the materials beyond the proper width.

The foregoing thickness is particularly recommended for gravel taken from the San Fernando pits, or from the beds of rivers and ravines, but for the metal from the quarries about Port of Spain, St. Joseph, or Glenroy a thickness of 8 or 10 inches laid in two or three courses will, I believe, be quite sufficient if carefully applied.

When round clear pebbles are used a small proportion of chalk, marl, loam, or fine gravel should be well mixed with the pebbles in order to bind them and to prevent their constant fretting and rolling against each other.

Although the process recommended above of laying three different courses will, likely, be very unpopular at first with contractors, yet I have no doubt that ere long they will find how beneficial it is for themselves by making their work much superior to that formerly done under the old system, almost without increase of expenditure, and by doing away with the unpleasant squabbling and difficulties so frequently arising before in consequence of bad work.

When broken stones are used care should be taken that their sizes never exceed 2½ inches. This is easily obtained by passing the metal through sieves with bars 2½ inches apart. The last or top course might be made of finer stones, but in no case whatsoever should large stones be allowed to be placed on the road.

During the metaling of any portion of a road proper measures should be taken to force the carts and carriages to pass, in turn, over every part thus newly metaled. This may easily be effected by placing heaps of stones at convenient places.

Depots of gravel or metal of 25 cubic yards each should be established at every one-fourth mile, and special laborers constantly employed in preventing the formation of any holes, ruts, or inequalities, etc.

The best time of the year for repairing the roads is the latter end of both the dry and rainy seasons.

At the end of the dry season the cross sections should be carefully corrected, the surface scraped, regraveled, and put in thorough order, the side trenches, outlets, main and catchwater drains properly cleansed, scraped, and reopened wherever necessary; the bridges* and cross-covered drains overhauled, cleared, and repaired; the depots of metal well filled up; the sides of the road cutlassed or better mowed,

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* All wooden bridges should be made of country hardwood, and white and pitch pine at once excluded from such works.

and, in fact, the road must be made ready to stand the effects of the heavy rains during the coming wet weather.

At the latter period the damage done during the wet season must be repaired without delay, the bridges and cross-covered drains examined and put to rights, the weak parts of the road reloaded with metal, and the road, in a word, must be again thoroughly overhauled and prepared to stand the heavy cartage of the ensuing crop season.

The sides of the roads should be regularly cutlassed or mowed four times a year, so as to insure at the nearest possible period the growth and formation of a low and thick green sward instead of the long grass and numerous weeds of all sorts that are now spoiling the appearance of most of our roads.

As soon as the frequent use of the cutlass shall have destroyed the brush on the sides of the roads the scythe must afterwards be exclusively used.

It does a much neater and cheaper work than the cutlass, and does not so much tear up and disturb the roots of the grass.

All grass and brush cut on the roads should be carefully removed.

No mud bank, scrapings, or rubbish of any kind should be allowed to remain on the sides of the roads.

The drains must, at all times of the year, be kept free from grass and rubbish, and the parties in charge of the roads should pay great attention to prevent the constant choking up of the channels with cane trash and plants, manure, etc., as is now practiced along most of the roads running through sugar estates, particularly at the junction of private roads or cane traces with the high road.

They should also take good care that the lopping of trees and clipping of live hedges be regularly attended to as prescribed by the road ordinance.

Generally speaking, all repairs of any importance should be given out by contract, and clauses entered in the deed of contract to provide for the faithful performance of the work within a fixed period, under penalties to be guaranteed by sureties.

Perhaps the best way would be to have printed blank forms for the different sorts of contracts generally to be entered into for the repairing and keeping of the roads.

Instead of relying entirely on tenders to know what repairs will cost, as is generally if not always the case now, the parties in charge of the roads should always, previous to calling for tenders, make, or cause to be made, a careful and correct estimate of what such repairs are worth, and being thus well acquainted with the value of the work to be done should never allow themselves to be taken in by the low figure of an ignorant contractor, but only accept of such contracts as are within a fair range and likely to prove remunerative.

SYL. DEVENISH, *Secretary.*

ASPHALTING OF STREETS.

TOWN SUPERINTENDENT'S OFFICE,
Port of Spain, Trinidad, June 24, 1890.

In regard to the results, etc., of the asphalting some of our streets I have the honor to submit the following brief notes on the matter:

(1) I am of opinion that the laying of asphalt is an immense advantage over the common macadamizing, and there is every reason to believe that it will last many years at a small cost of keeping. The principal advantages are:

(*a*) To be almost noiseless and offer very little resistance to traction.

(*b*) To be free from mud in the rainy season and from dust in the dry season.

(*c*) To offer good sanitary conditions without emitting any perceptible unpleasant smell.

(2) Hitherto we have used asphalt in its crude state, pulverized by hand with cast-iron rammers and applied cold on our already macadamized streets, on which it is

either rammed as above or rolled by steam, and I am convinced this is quite sufficient and will answer well here, instead of having recourse to the complicated and expensive system followed in America, where the asphalt is boiled, etc., and laid at a cost of about $4.50 per square yard. (See the interesting and exhaustive pamphlet "Genuine Trinidad Asphalt," published in Washington by the Barber Asphalt Paving Company.)

(3) Of course our asphalt street work is as yet in its infancy and only an experiment, in which we must necessarily gradually gain experience, and it remains to be seen what will be the ultimate results.

(4) The principal cause of complaint against it, and I believe it to be the only one (cost excepted), is its great slipperiness in streets in which, owing to the high level of our tramways, a much over curved cross section has been unavoidable, but in other streets this complaint has scarcely ground to go upon.

(5) The advantage we have here is that our streets, being almost all macadamized, it only requires a scooping out of a few inches, and the ground below is generally firm and hard enough from the lower remaining macadam to receive a mere top dressing of about 2 to 3 inches of pulverized asphalt.

(6) The asphalting of our streets will, in future, be much improved from our past experience, and I have no doubt that it will give universal satisfaction and will prove a great boon to our town.

(7) It is my intention to try, if allowed to do so, a small proportion of fine sand to be mixed with the asphalt, so as to render the surface a little gritty, and do away with the present sleekness to which, however, our horses are gradually getting accustomed.

(8) The facility of procuring asphalt from our pitch lake at 10 a ton, delivered on the wharf, is, it must be said, a great deal in our favor, whilst in Demerara the cost will necessarily be much greater.

(9) On a rough calculation it takes us about 3¾ cart loads (of 12 cubic feet each) of asphalt to the ton.

(10) One such load will cover about 50 square feet or 5.55 square yards from 2 to 2½ inches thick.

(11) The average cost of working our steam-roller is about $5.35 per diem.

(12) Hitherto the steam-roller has only been able to roll about 666 square yards daily, but more will, no doubt, be got out of it in future.

(13) We calculate that it takes during 10 to 12 days ten or twelve laborers daily employed in digging, pulverizing, and laying for preparing sufficient pitch for 2 days steady steam-rolling.

(14) One hundred square yards of asphalting has cost us in the southern division of the town, where the traffic is very great and the streets consequently much worn out, $37.58, whilst metal and sand would only cost about $20, or about 52 per cent. less, but for work not to be compared with the new coating.

(15) In the northern division we have slightly asphalted, under much better conditions, 9,601.68 square yards of streets at an average cost of about 25 cents per yard, but with the intended improvements I believe this may probably be increased to 35 cents.

(16) The use of asphalt is particularly of the greatest advantage in protecting the sides of the roadway and the corners of the streets, where the rush of storm water in heavy rains constantly washes away the macadam and digs deep furrows and holes.

SYL. DEVENISH,
Town Supt.

DANISH WEST INDIES.

ST. THOMAS.

REPORT BY CONSUL HORNE.

CITY STREETS.

The local government is unable to give me the estimated cost of making or repairing the streets of this city, *i. e.*, "Charlotte Amelia." They were made, of broken stone, upwards of a century ago, and are kept in repair by using similar material, the stone being broken fine by convict labor. The depth of the broken stone is about 20 inches. The streets are slightly oval and smooth and of great solidity. As they are not subject to either frost or heavy traffic, the annual expense of keeping them in repair is very small. Convict labor is utilized in breaking stone and keeping in repair the city streets and such portion of the country roads as are necessary for use. The streets are substantially bordered on either side by gutters made of irregularly-shaped but nearly flat stone, which are laid in and evened up by a hard cement. The sidewalks are mostly composed of material, similar to those employed in making the gutters.

COUNTRY ROADS AND HIGHWAYS.

There is no "ordinance" governing the making or repairing roads and highways in this island (Saint Thomas). The abandonment of the estates, following soon after the emancipation of the slaves, has caused the country roads to fall into disuse. Country traffic has practically ceased and the roads are but little used.

I inclose herewith a copy of the "ordinance concerning public roads in St. Croix." It contains all the information which Mr. Moore, the consular agent there, has been able to obtain on the subject of streets and highways.

SAMUEL B. HORNE,
Consul.

UNITED STATES CONSULATE,
St. Thomas, January, 14, 1891.

ST. CROIX.

OFFICIAL ORDINANCE TRANSMITTED BY CONSUL HORNE, OF ST. THOMAS.

I. GENERAL PROVISIONS.

§ 1. The public roads in St. Croix are divided in two classes: (1) Main roads, the width of which between the trenches shall as a rule not be less than 36 feet, with graveled roadway not less than 14-18 feet in width; and (2) by-roads, the width of

which between the trenches shall as a rule not be less than 24 feet, with roadway not less than 10-14 feet in width.

§ 2. A list of existing roads of both classes shall be issued by the superior authority and published in "St. Croix Avis."

Upon agreement to that effect with the colonial council, government may include new roads among the number of the existing pubilc roads, or discontinue existing public roads as such, which alteration shall be published in the same manner.

§ 3. The superior authority is empowered to grant permission to lay down tramways on the public roads, subject to such stipulations as are requisite to insure that the general traffic be not hindered, and that the parties having to discharge the repairs of the roads do not by such tramways get increased burden of road work.

§ 4. Quarter lines as well as private roads of communication between estates shall generally be 24 feet in width and shall be kept open and in good order to same extent as hitherto.

II. Control with the Roads.

§ 5. The public control with the roads is exercised through a road commission, consisting of a chairman, appointed by the superior authority, and eight members, half of them elected by the superior authority, the other half by the colonial council, in such wise that for each of the eight quarters of the island one member is chosen from among the residents of the quarter, as a rule from among the proprietors of landed estates. The election shall be for a term of 5 years, but only the half of the number of members shall retire at a time. Five members shall constitute a quorum. The superior authority is empowered, whenever it be deemed necessary, to dissolve the road commission and to cause new election to be held.

§ 6. The control with the state of the roads in each quarter shall be performed by the member of the road commission appointed for the quarter, who has to make the necessary reports to the chairman. To assist the members of the commission there shall be appointed such a number of road inspectors as the superior authority upon representation of the commission shall at any time find necessary.

§ 7. Every owner, administrator, or manager of an estate who has not completed his 60th year is obliged to accept election as member of the road commission or appointment as road inspector, unless the superior authority or the colonial council, if he has been elected by this latter, on his application to that effect, should find cause to exempt him. The road inspectors are appointed for a term of five years, at the expiration of which they are during a term of the same length entitled to exemption from such charge.

§ 8. The chairman of the road commission is salaried with $300 p. a. The road inspectors shall receive a compensation of $32 p. a. each.

§ 9. The duties of road officers are to be fixed and defined by instructions issued by the superior authority; which instructions shall also contain the necessary rules for the business routine of the road commission, for the election of members of the commission, etc.

III. The Road Work.

§ 10. The duty of keeping the roads in every quarter in good and serviceable condition is incumbent on the owners of landed properties, factories, and similar establishments situated within the quarter. The works required for that purpose are effected in such a manner as shall be prescibed in regulations issued by Government upon conference with the colonial council.

§ 11. By means of assignment to be effected every fifth year, every property is assigned the allotment of roads which is incumbent on the property to keep in repair.

The assignment in which should be considered the quality and location of each allotment, if it is part of a main road or of a by-road, if it is particularly easy or

difficult to keep in repair, if it contains water courses or not, etc., is made in proportion to the matriculated acreage in cultivation of the respective properties in such a manner that one acre of land in sugar cultivation is considered equal to 5 acres in other cultivation, and that no land is exempted, except land from which no use or benefit whatever is derived. The road work incumbent on factories and similar establishments is fixed by the superior authority.

The maintenance of the pavement or the bridge of a water course, or other more extensive works of repair, may be assigned to several estates jointly. Likewise any work of repair may be assigned several estates jointly, provided these estates are so small that it would be inexpedient to assign to each a separate work of repair.

§ 12. For each quarter separately a draft of the assignment is drawn up by the respective member of the road commission in conjunction with the road-inspectors of the quarter, and is transmitted before the 1st July in the year in question, to the road commission, who, on the basis of the drafts, draws up a draft of assignment for the whole island, which draft shall be transmitted in duplicate to the superior authority before the 1st August, and the said authority thereupon, by publication three times repeated in the newspaper of the island, shall inform the parties concerned that copies of the assignment have been placed for inspection in the police offices, and eventual objections to the assignment must be made within 14 days of the last publication. On the expiration of this term, the superior authority decides on the objections that have been sent in after having taken the opinion of the road commission and confirms the assignment according to such decision, upon which one copy of the assignment is transmitted to the road commission, who, through the members of the road commission and road inspectors, conveys information to all concerned of the allotment of road assigned to each property.

The bounds of the different allotments shall be exactly indicated, before the 1st October, by conspicuous posts bearing the mark of the property and planted by the roadside.

§ 13. The public roads, with bridges, courses, breastwalls, handrails, etc., thereon found shall undergo general repairs every year, such repairs to commence the 1st October and to be completed before the 31st December.

§ 14. Every year in the course of the month of January a general inspection of the road works takes place, to be held for every quarter by two members of the road commission and two road inspectors, all of whom are appointed for the purpose by the chairman of the commission, and must be residents of another quarter.

The member of the commission for the quarter to be inspected shall however receive notice to be present at the inspection; he is entitled to point out defects, but has no vote in the decision,

§ 15. When defects in the road work are discovered by the inspection, there shall be given the holder of the allotment, who is, moreover, liable to penalty under § 24, a suitable term, within which he is to have the defects remedied. Should he find himself aggrieved by the decision of the inspectors, he may within 8 days demand a reinspection, which is effected by the road commission, with exception of the two members, who had taken part in the first inspection, and at which the party shall eventually be given the further necessary term. The decision of the reinspection settles the matter.

If the defects are not remedied at the expiration of the term, the road commission shall, on the report from the inspectors in case no reinspection has been held, have the work done at the expense of the concerned party. The expenses for the purpose inclusive of such remuneration for the controlling member as may be fixed by the superior authority on the representation of the commission, are to be enforced by levy, unless the holder of the allotment alleges that the work is not incumbent on him, that the above mentioned term had not been given him or he advances any other similar objection, in which case the decision shall be given under a public police suit instituted against him.

§ 16. Besides the yearly general repairs such repairs as shall be needful for keeping the roads in a proper state—such as filling up of small holes, leveling the surface, repairs of side-walls, bridges, and the pavement of water courses—shall be effected at all times of the year, when ordered by the member of the road commission. The order so given, and for the fulfillment of which a suitable term shall be allowed, is final when the cost of the work does not exceed $5, otherwise the party concerned may within 4 days demand that the case be submitted to two other members of the commission, chosen by the chairman in conjunction with the first-named member; their decision, whereby eventually the necessary additional term is allowed, settles the matter. If the defects are not remedied at the expiration of the term, the road commission shall, on report to the same, have the work done at the expense of the concerned party. The expenses for this purpose, inclusive of a remuneration to the controlling member fixed in the same manner as prescribed above in §15, may be enforced in the manner prescribed in § 15.

§ 17. When bridges and considerable lengths of road, the maintenance of which devolves upon any single party, are so extensively damaged by heavy rains that the road commission finds it inconsistent with equity to charge him with the repairs, such repairs shall be distributed among the properties in the quarter in the same proportion as the road allotments. Under extraordinary circumstances the public may, however, according to decision of the superior authority, assume the repairs entirely or in part.

§ 18. Whenever a work of repairing is incumbent on several properties jointly, the work is under the direction of the member of the road commission or such person as the chairman of the road commission may depute. Otherwise, the allotment holders are at liberty to consult their own convenience as to the most suitable manner of promoting the work, which, notably, may be given in job, but such arrangement does not affect the allotment holder's responsibility to the public.

§ 19. Should any holder of a road allotment prefer that the repairing of the allotment assigned to him be effected by public agency, and he addresses written application to that effect to the road commission, the work in question will, by order of the commission, be effected by and under the direction of the road inspector of the district, on condition that the applicant, when the work is completed and approved by the inspection, pays the expense of the work, including a suitable remuneration to the road inspector who has superintended the work.

The account of the expenses incurred is forwarded to the superior authority by the road commission who at the same time makes proposal as to the remuneration which should be allowed the road inspector.

When subsequently, all the expenses have been approved, the superior authority assigns the account for payment against the holder of the road allotment, who is bound to pay the amount into the colonial treasury within 14 days. In regard to the payment of the amount in queotion, the colonial treasury holds the same right of levy and preference as it holds for taxes.

For temporarily defraying the amounts for these, as well as for the works mentioned in §§ 15 and 16, the necessary advances may be assigned to the road commission from the colonial treasury.

§ 20. The construction of new roads is effected and expenses defrayed by the public. The maintenace of such a new road devolves upon the road allotments of the quarter in proportion to be fixed by additional assignment.

§ 21. The public is charged with making provision that the necessary gravel pits are to be found as near as possible to the road.

In default of amicable arrangement with the owner regarding compensation for the use of the ground at gravel pit, the area required for the site of the gravel pit, and needful access thereto, shall be expropriated and the value thereof fixed by two experienced and impartial men appointed by the court, in such a manner that each of the interested parties shall have access, before the legislation of the appraisement,

to demand reappraisement by the double number of men. The expenses of the appraisement are defrayed by the public in such a manner, however, that the expenses of a reappraisement demanded by the owner and the issue of which is against him are defrayed by the owner.

§ 22. The same proceeding is applicable in the case of cession of ground for the construction of new roads.

IV. Penalties, etc.

§ 23. Neglect of duty and disciplinary offenses on the part of road officers are punished, in so far as they are not liable to more severe penalties, with fines of not less than $5 and not exceeding $25, which accrue to the colonial treasury. The fines are dictated by the superior authority. In regard to other offenses committed by road functionaries or against such while on duty, the general enactments of law are applicable.

§ 24. Any holder of a road allotment who is found at the annual inspection in the month of January to have omitten to complete the road work incumbent on him, or to have performed it in an unsatisfactory manner, is liable to a fine not exceeding $50.

§ 25. Any holder of a road allotment who fails to comply with an order from the properly qualified officer or authority, at any time soever in the year, concerning the repairing of his road allotment or anything belonging thereto, is liable to a fine not exceeding $25. The same fine shall be adjudged against any person omitting to plant the bound posts mentioned in § 12.

§ 26. Cases concerning the offenses mentioned in § § 24 and 25 are dealt with as public police suits, at the instance of the road commission. The road commission, is however, before the case is reported to the policemaster, authorized to accept the delinquent party's offer to settle the matter amicably by fine to be paid forthwith. Concerning such settlements the road commission shall make report to the superior authority. Fines adjudged or agreed to under the present section accrue to the colonial treasury.

§ 27. If the holder of a road allotment is not residing in St. Croix citation in the cases in question may be lawfully served on the person who administrates his property here, with notice to be determined according to the residence of the person thus empowered.

§ 28. On every vehicle which when loaded weighs 3,000 pounds or upwards, the felloes of the wheels shall be at least 3 inches broad. Transgressions of this provision shall be liable to penalty of a fine of not less than $2 and not exceeding $10. Cases of non-compliance are dealt with as public police suits.

§ 29. Upon conference with the colonial council, the superior authority issues regulations containing provisions for the road police and for the maintenance of public peace and security of and on the road, including the preservation of the trees growing along the roads, which trees must not be felled in a space 6 feet from the trenches. Fruit of trees along the public roads belong to the owners of the adjoining properties.

§ 30. Transgressions from the regulations mentioned in § 29 are dealt with in public police suits, and are punished with fines not exceeding $50, which accrue to the police fund. In the case of children under 15 years the punishment of flogging with a rod may be inflicted according to circumstances.

DUTCH WEST INDIES.

CURAÇOA.

REPORT BY CONSUL SMITH.

CITY STREETS.

The island of Curaçoa, being of coral formation, with very little soil, makes the building of smooth and level streets easy, and when built they can be maintained at a small expense.

In places where there is not a solid roadbed of stones, or the surface is uneven, the way is laid out and covered with clay, and over this a paving of coral stones is placed. The stones used for this purpose are taken from the shores of the island, and will average about 6 inches in diameter, and are round in shape. They are broken in suitable lengths, placed on end and driven into the clay, made soft by water to receive them.

These small paving stones are confined within the line of the street by a border of large square or flat stones, and when driven by wooden drivers they are wedged together so that they can not be removed easily; sand is then placed over the surface and sifted into the crevices.

This makes a fine street where there is no heavy traffic, but the coral is too soft to be serviceable where there are heavy teams passing over it.

The cost of such paving here to the government is about $1 per square metre.

COUNTRY ROADS OR HIGHWAYS.

All over the island are estates which are accessible by fine public roads provided and maintained by the government, and under the surveillance of an inspector appointed for that purpose.

The comparative level surface of the island is very favorable for the construction of country roads, no bridging and very little cutting being required. The surface of the road is covered with small broken stones or gravel, and when this is made fine by travel and becomes wet by rains it unites. The roads are made somewhat higher in the center, or turnpiked so that water will not stand on them. There are no rivers or streams for these roads to cross, so no bridges are required, but during very heavy rains large streams of water cross the roads in many places, and water ways are provided therefor. These are made of large, flat stones laid, not like a bridge, but with a concave surface for the water to run over.

The annual expense to the government for the maintenance of these roads is about $2,300, including the salary of an inspector.

L. B. SMITH,
Consul.

UNITED STATES CONSULATE,
Curaçoa, January 29, 1891.

SPANISH WEST INDIES.

PORTO RICO.

REPORT BY CONSUL STEWART, OF SAN JUAN.

STREETS OF SAN JUAN.

The streets of this city are very narrow, and are paved with small, round stones. The sewerage consists (with the exception of a portion of two or three of the most principal streets having underground sewers) of small gutters in the center of the streets, formed by a slight downward slope from each sidewalk. With the exception of this slope the sidewalks are on a level with the rest of the street. The crevices between the round stones are not filled, therefore the streets are very rough, and neither beasts nor vehicles are spared upon them for any great length of time.

COUNTRY ROADS.

In the entire island there are about 150 miles of excellent road, and of this alone it is necessary to speak, since this is all that receives any attention. In its construction a level foundation is sought, and upon this is put a heavy layer of crushed rock and brick, which, after having been well packed and rounded, is covered with a layer of earth. This is then well packed also, and upon the whole is spread a layer of ground limestone, which is pressed and rolled until it forms almost a glossy surface. This makes an excellent road here, where the climate is such that it does not affect it, and where there is no heavy traffic; but these conditions being changed, the road, it is thought, would not stand so well; hence further particulars are deemed useless.

L. R. STEWART,
Consul.

UNITED STATES CONSULATE,
San Juan, December 30, 1890.

SANTIAGO DE CUBA.

The only thing that saves this city and allows carriages and native horses to pass the lanes and roads, by courtesy called streets, is the composition of the soil, viz, decomposed coral rock, in which lime forms a large percentage. The streets are in a deplorable condition; the city being bankrupt, nothing is done to improve them. The country roads are mere trails, impassable in the rainy season.

OTTO E. REIMER,
Consul.

UNITED STATES CONSULATE,
Santiago de Cuba, December 6, 1890.

FRENCH WEST INDIES.

GUADELOUPE.

REPORT BY CONSUL BARTLETT.

The colonial or county roads are built and kept in repair at the expense of the Colonial Government. If a new road is to be built, all the loose earth is removed until they reach a hard substantial surface, then it is filled in with broken stone, about the size of eggs, and beat down thoroughly with mauls, and then fine, dry earth is spread on same, enough to cover them about a couple of inches, and again beat down thoroughly. This is generally let out to contractors.

The expense for building new country roads is about 10,000 francs per kilometre, and to keep the same in repair, it costs about 1,000 francs per annum per kilometre. The center of the streets in the city is made in the same way as the colonial roads, with the addition of 1 metre in width, on each side of the streets running down to the gutters, which is made with broken stones, laid in cement, at an additional cost of about 36 francs per cubic metre. The stone flagging for the sidewalks of the streets, if in artificial stone, costs 16 francs per running metre. The stone to be 35 centimetres wide and 15 deep; if the flagging is of calcareous stone, which is easy to work, it costs 140 francs per cubic metre; if composed of volcanic stone, which is very hard and very difficult to work, 200 francs per cubic meter. The street once built, the expense for keeping them in repair is about the same as colonial roads.

I will mention here that the expense of 10,000 francs per kilometre, for new country roads, is exclusive of bridges and culverts.

The quay of the city of Pointe-à-Pître, where the principal commercial business is carried on, is paved with cobblestones of a volcanic nature, gathered from Guadeloupe proper, at a cost of 4 francs per square metre, and the expense for maintenance is about 2 francs per annum per square metre.

Government or public roads going through properties naturally augment their value.

The principal government roads are very fine and are kept in good repair; but there are very few of them: There is one, extending 66 kilometres, from Pointe-à-Pître Grande-Terre to Basse-Terre Guadeloupe proper, by crossing the Rivière-Salée in a ferry, passing through Petit Bourg, Goyave, Sainte Marie, Capesterre, Trois-Rivières and Gourbeyre; another 120 kilometres long, after crossing the Rivièrre Salée, goes by the northern part of Guadeloupe, to Basse-Terre, passing through Baie-Mahaulto, Lamentin, Sainte-Rose, Pointe-Noire, Deshaies, Vieux-Habitants, Bouillante, and Baillif. There is a short public road from Basse-Terre to Matouba, of about 10 kilometres, passing through the Camp Jacob. There is another short one, recently con-

structed by disciplined soldiers, from Camp Jacob across to Gourbeyre from 4 to 5 kilometres in length.

There is a Government or public road going from Pointe-à-Pître to the Moule, passing through Gosier, Sainte-Anne and Saint-Francois of 50 kilometres, and another one going from Pointe-à-Pître to the Moule, passing through Abymes, Morne-à-l'Eau or Gripon of 30 kilometres and one from Gripon to Anse-Bertrand of 20 kilometres, passing by Port Louis.

These are all the principal public roads existing in Guadeloupe proper and Grande-Terre.

The planters, for their own convenience, make their own roads to their different estates, and at their own expense. Generally these by-roads are not kept in very good repair.

CHARLES BARTLETT,
Consul.

UNITED STATES CONSULATE,
Guadeloupe, July 7, 1891.

CONTINENT OF ASIA.

BRITISH ASIA.

BOMBAY.

REPORT OF VICE-CONSUL BODE.

I have the honor to send herewith a copy of a report from the executive engineer, Bombay municipality, on the subject of street building and road making, as per circular, dated November 8, 1890.

A. E. BODE,
Vice-Consul.

UNITED STATES CONSULATE,
Bombay, April 23, 1891.

MUNICIPALITY OF BOMBAY.

B.

Mr. Walton, engineer, to Vice-Consul Bode.

BOMBAY, *April* 6, 1891.

H. A. ACWORTH, Esq., C. S.,
Municipal Commissioner.

ROADMAKING.

In making new roads the earthwork is first prepared with a surface fall of 1 in 40 from the center to the sides where the width of the road is 40 feet and under. Where the width of the road is greater than 40 feet a fall of 1 in 50 is used. The surface is consolidated with 4 or 5 ton bullock rollers, or with steam rollers, preferably with the latter in the dry season. On this a layer of dry rubble packing of a thickness of 9 inches to 12 inches in the case of the roads of the first two classes, and of 6 inches in that of the others is hand packed solid. Over this are laid two layers of 2-inch road metal in aggregate from 6 to 12 inches in thickness, according to the traffic and importance of the road. The first layer is thoroughly watered and rolled until it is partially consolidated. The second layer is then spread and watered and rolled with steam rollers until the whole is fairly consolidated. About half an inch of loose sandstone* is then spread on the surface of the road and steam rolling is continued and hard level surface is the result. On each side of the road, especially where there are footpaths, bluestone, chisel dressed water table stones 4 inches thick and from 15 to 18 inches wide are laid to carry away the storm water into proper masonry gully-traps. Roads thus made wear under heavy traffic about six years without any extensive repair.

*A soft littoral concrete.

MAINTENANCE AND REPAIR.

In order to prevent the metal of these roads becoming loose it is necessary during the dry season to water the roads morning and evening, and to repair slight defects as they appear in the surface promptly. New roads are constructed, as a rule, by contract. Repair works are carried out departmently by a staff engaged for the purpose. When the road requires thorough repair the surface is picked up in continuous convenient lengths to a depth of about 4 inches for one-half the width of the road at a time in order that the traffic may not be stopped. On an average one native pickman, working 8 hours, picks 200 square feet of metailed road. The old metal if serviceable is separated from the fine stuff (which is rejected) and spread over the picked surface. New road metal is put over this to the required depth, giving the proper slope to the surface. This is consolidated as described of new roads.

The total length of the street in the charge of the municipality is 138½ miles and the area of the metaled part of such roads is 3,110,605 square yards. Footpaths are not included. The annual cost of maintenance of metaled part of roads is as follows:

	Rupees.
Cost of watering for the nine dry months in the year	93,270
Cost of metal and other materials for street repair	162,000
Cart hire in connection with street repair	92,000
Labor in connection with road repair	95,000
Steam rollers	16,000
Coals and stores and repairs	24,500
Total	482,770

Or 155 rupees per square yard.

The effect on the rate of land fronting a new road was recently well exemplified in the construction of the Ripon road. While taking up land for this road an endeavor was made to purchase frontage lands along the line of this road. But on account of the strenuous oppositions of the owners of the land to part with more land than that required for the road, only a part of the frontages could be purchased. The total area of land purchased was 68,750 square yards, from which, deducting 26,289 square yards required for the road, and 5,157 square yards for cross roads, making a total deduction of 31,446 square yards, there remained a balance of 37,304 square yards available for resale. The cost of land, including compensation, amounted to 163,633 rupees; the cost of road construction and establishment amounted to 65,679 rupees; sale charges amounted to 9,000 rupees, making a total of 238,312 rupees, from which, deducting miscellaneous receipts, rent, sale of materials, amounting to 6,806 rupees, there remained 231,506 rupees as the actual cost of making Ripon road, including also charges for land and compensation to private owners. The land was bought at a price averaging 75 rupees per square yard.

The surplus area was sold by public auction at rates averaging 7.23 rupees per square yard.

In addition to the direct profit made by constructing the Ripon road, revenue of the municipality was increased by the buildings which were built fronting the road after its construction.

The amount of such increase can not, however, be given, even approximately.

RIENZI WALTON,
Executive Engineer, Municipality.

True copy.

W. PEARSON,
Assistant to Commissioner,
E. M. S.

UNITED STATES CONSULATE AT BOMBAY.

CEYLON.

REPORT BY CONSUL MOREY.

Department of State instruction per circular of November 8, 1890, was received here at a period when the furnishing of a truthful and thoroughly reliable report on the roads of Ceylon was beyond my capacity.

Mr. MacBride, the director of public works, had on his accession to office in 1885 adopted a new system (or a modification of his own of the Macadam system, hitherto in vogue) and was working it with great perseverance, despite an amount of public detraction that might well have deterred a less able and determined man.

The fierce diatribes against him and his roads, constantly appearing in the newspapers, if cut out and preserved, would form a large volume of the harshest criticism extant, and there was nothing to offset them in the literary line except his own periodical reports to the Government, all of the facts in which were stoutly denied by the great army of dissentients as soon as they appeared.

I myself at one period feared that Mr. MacBride had fallen upon a wrong system, for the outcry against him was loud and fierce enough to shake the confidence of almost anybody. I knew, however, that Sir Arthur Gordon, the then governor of the colony, who had traveled largely over these roads and was a very keen observer, thoroughly believed in the new system and meant to back Mr. MacBride up in it, through "good and evil report," to the bitter end.

I was also in the way of hearing traveled countrymen of my own express admiration of the excellent roads they found wherever they went in Ceylon, and, as their opinions were bound to be dispassionate, they counted heavily against the local utterances, which after all might be largely due to prejudice, predilection, or what is popularly called conservatism.

On my return to the island from leave in 1890 I found the newspaper war on the roads as fiercely conducted as ever, but there was nevertheless a faint murmur of approval getting into the air, and it gradually got whispered about that Mr. MacBride and his highways had scored.

It was about this period of growing reaction that my instruction to report on roads arrived, and as it was MacBride roads that must form the subject of my report, and said roads, after being decried for years, were now just receiving some approval, I felt bound to await future developments before reporting upon the system.

By the end of the year 1890 the denouement came. The roads were unquestionably good, and they had been built and kept up at a diminished cost, as against the old system, of the large sum of 850,000 rupees per annum. Detraction now ceased, newspapers withheld their philippics, and in some cases even made the amend honourable to Mr. MacBride.

Now was the time to make my report, but alas! Mr. MacBride went away on duty to India, and there remained as data for my guidance only his reports, which the newspapers had contradicted *ad inifinitum*, and which being intended only to meet local requirements scarcely afforded explicitly the information my Government desired.

I was obliged therefore to await Mr. MacBride's return, and on his arrival I waited on him and requested the favor of such data as would enable me to make an intelligent and truthful report. This he kindly agreed to give as soon as he could spare time from his own pressing duties to collect it, and the final result is, the annexed, able, and exhaustive exposition by his pen, which, as I could not add to it profitably a single word of my own, he has courteously allowed me to forward in its entirety.

I would merely add, in conclusion, that the roads in Ceylon attain an altitude of over 6,000 feet above sea-level, and are subject to damage, principally from rains and floods, the rainfall sometimes amounting to 260 inches per annum, and in certain localities 12 inches per diem, and 8 inches have been registered in two hours.

They are, however, exempt from the action of severe frost, for this climate is highly tropical, Ceylon being situated only a few degrees from the equator, say between 5° 56″ and 9° north latitude.

W. MOREY,
Consul.

UNITED STATES CONSULATE,
Colombo, July 8, 1891.

Mr. MacBride to Consul Morey.

COLOMBO, *Ceylon, July*, 2, 1891.

W. MOREY, Esq.,
Consul of the United States of America, Colombo:

SIR: With reference to your visit of May last, and request that I should furnish you with information regarding the construction and maintenance of public roads in Ceylon, and the cost thereof, I have the honor to forward herewith a paper on the subject, which I trust will be found of practical interest to the Department of State concerned.

There is no greater boon to give to a populous country than roads; when we find them outside our doors every day of our lives we look upon them as very ordinary things, and think little of them, but go to any part of Ceylon or to any country where there are no roads and you will find every able-bodied man, and woman, too, turned into a beast of burden. I believe roads confer more good on a people than anything that laws can cause or cure.

The direct revenue of roads is that derived from tolls. In Ceylon it amounts to about 450,000 rupees, but besides they give an impetus to trade and are instrumental in developing the resources of the country.

The policy of the government of Ceylon in regard to its roads is one of efficiency combined with economy, whereby all roads receive equal and adequate attention in proportion to the traffic passing over them.

I am, sir, your most obedient servant,

R. K. MACBRIDE,
Director of Public Works.

ROADS IN CEYLON.

[Report by Mr. MacBride, director of public works in Ceylon.]

The roads of Ceylon are, as a rule, well and solidly constructed, and maintained in a thoroughly efficient state for the traffic they have to bear.

These results are attained by the votes given by the government for such services, and by careful attention to every detail by the department of public works.

It is unnecessary in Ceylon to distinguish between "city streets" and "country roads or highways." The only city in Ceylon is Colombo, with a population of 120,000, scattered over an area of 10 square miles. The roads in Colombo are dealt with in much the same way as those in the country, and cost but little more per square yard for construction or maintenance.

TRACING ROADS.

The line of road to be opened in a new district is located by an experienced engineering surveyor, with a due regard to the traffic to be served. Trial lines are usually run in the first instance with a simple instrument known as a "road tracer," with which gradients can be readily located. The line is then traversed with the theodolite, the traverse connected with trigonometrical stations, and then a longitudinal section and cross-sections every 100 feet are taken with the Dumpy level.

A gradient of 1 inch in 20 is considered the maximum that should be permitted in a first-class road.

Zigzags are only permissible when the features of the country are so rugged and precipitous that their adoption is obviously advantageous; but when adopted, their construction for a radius of 50 from the turn on each side is level. This slightly increases the gradient, but the traffic ascending or descending is steadied on a level roadway at each turn, and the draft animals are thereby relieved of the heavy strain.

Owing to the extremely steep and broken nature of the hill country of Ceylon the roads, as a rule, are in sidelong or double cutting; in the low country, where, due to the heavy rainfall, floods occur almost annually, long embankments with numerous waterways and double cuttings are frequent.

The road trace having been made and approved, and the estimate for its construction framed and passed by the government, the construction proceeds as follows:

Cooly lines or rude huts of wattle and daub walls and thatched roofs are erected at convenient points on or near the line of roadway, attention being given to the water supply and drainage, and gangs of Tamil laborers are employed to cut out the earthwork, blast the rock, and remove bowlders until a roadway of 16 feet in the solid to the gradient laid down on the plans is obtained. At the same time the building of culverts in all ravines and of others to take the side drainage of the road, proceeds. These cross culverts have, as a rule, an opening of 3 feet in height, by 2 wide; they are of dry hammer-dressed rubble masonry. A rough floor, about a foot in thickness, is laid, on which the side walls are built and then cover stones with sufficient bearing are selected and the masonry is carried up to road level, and occasionally finished off with a low parapet wall. The larger streams have two, three, or more openings and of longer size and, if 12 feet or more waterway is required, arched bridges of masonry or iron girder bridges with buckled-plated and concrete platforms are used. Partially worn out rails from the government railway have also been extensively used for bridging these smaller streams. Timber, some years ago extensively used for bridging, is now seldom adopted, owing to the extremely rapid decay, of such material in the tropics, and the destruction by white ants to which it is exposed. The larger streams and rivers are bridged, usually, with iron girders, of which very numerous patterns have been adopted in different localities, some imported from England and many made in the public works factory in Colombo. The largest spans hitherto adopted are 150 feet.

SURFACE TO CARRY THE TRAFFIC.

The roadway being so far constructed a layer of foundation stone 6 inches to 9 inches deep is laid by hand to a width of 14 or 15 feet; on this is spread a layer of 3 inches of broken metal, broken by hand, in cubes to pass through a ring of 2 inches diameter, however held, and the surface being finished with a very small quantity of clean gravel is consolidated, with iron rollers weighing 35 cwts., drawn by native bullocks, and a liberal application of water, a side drain about 2 feet wide and 18 inches deep is cut on the inside in side-long ground, or both sides in double cutting.

MATERIALS USED IN CONSTRUCTION.

Abundance of good stone exists almost everywhere in Ceylon; it is gneiss, a metamorphic rock, in a few places so clearly stratified as to render it easy to wedge it off from the quarry face in blocks suitable with but little dressing for the best masonry. The same stone, which is indeed the predominant geological feature of Ceylon, is used for the foundation and the metaling. Quartz gravel is common in certain parts of Ceylon, and where it is not found a fairly good hard gravel, known locally as cabook* gravel and abounding in clay iron stone, is found. This is in the formation known geologically as "laterite." Hardwood timber is scarce and difficult to obtain in the Central Province and other settled districts, and owing to the large consumption of fuel on tea estates is becoming more so every year; in the low country it is abundant.

Lime in the form of bowlders of almost pure carbonate of lime is found all over Ceylon, but the lime for mortar obtained from burning this stone is comparatively poor in quality as a building material. The best lime obtainable in Ceylon is made of coral, found everywhere along the seaboard, but rates of transport (Ceylon is not a horse or draft cattle breeding country) make its use in the interior expensive.

Portland cement imported from England is largely used for work exposed to wet and for concrete foundations, where such are necessary.

LABOR.

The labor employed on both the construction and maintenance of Ceylon roads is chiefly Tamil, originally from southern India. Though not physically equal to Europeans, Tamil coolies can do a good day's work and are housed and fed at a minimum of trouble and expense. Their pay ranges from 32† cents of a rupee to 42‡ cents for ordinary coolies, 50§ cents to a rupee for artificers, miners, builders, and carpenters, a rupee to two and a half rupees for highly trained artificers and foremen.

TOOLS.

The tools used in road construction and maintenance are much the same as are in use in Europe, but the spade and shovel are almost unknown, their place being taken by a tool called a mamoty, in shape like an adze,‖ but with a broad flat blade. Wheelbarrows are unknown, transport of material being chiefly performed by wicker-work baskets carried on the head, or by iron carts dragged by hand.

Trained elephants are used on road construction, especially in remote districts, where machinery and appliances for lifting or moving heavy weights are not to be had. The elephants drag stone on rough sledges formed of the fork of a small tree, to which they are attached with a rope collar and chain traces. They also can move enormous weights with their heads, and will exercise great care and intelligence when well directed in placing heavy stones in position on masonry works. Transport is also carried on with bullocks working in two-wheeled carts.

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* Laterite. † 12½ cents. ‡ 15 cents. § 18 cents. ‖ A clumsy hoe iron.

COST.

The average cost of first-class metaled and well-bridged roads in the hill country of Ceylon is 20,000 rupees* per mile; in the low country about 12,000 rupees.† Graveled roads cost about 5,000 rupees less per mile in each case.

The rupee, at the present value of silver, is worth about 1 shilling and 5 pence in English money; thus 2.83 rupees represents the value of an American dollar. The cost, therefore, of a first-class metaled road in the hills would be in American money about $7,067 per mile, and the cheapest road in the low country $2,473 per mile.

MAINTENANCE OF ROADS.

As before stated, the roads of Ceylon are maintained in a very efficient state; the surface and the drainage receive the most careful attention; a skilled European officer of public works is in charge of each departmental district, having about 100 miles of principal roads. He is under the direction of the chief engineer of the province and has under him a staff of native overseers and clerks. The system on which the roads are now maintained, known locally as "the MacBride system," was introduced in the year 1884 by the writer, the present director of public works (Mr. R. K. MacBride, C. M. G.), and was designed to introduce road reform, which was greatly needed in the colony, and to render dishonesty and peculation among the native overseers almost impossible. It has already saved the colony an expenditure of 3,500,000 rupees.

The amount of broken metal required annually to keep up the surface of the road and replace that worn away by the traffic has been learned by long experience with considerable accuracy. The work of the year commences by breaking this metal in the quarries adjoining the road, and either piling it continuously along the sides of the road to be repaired or in convenient depots at short distances apart. As a rule no metal is used until all is broken for the year, but a small reserve is always kept for the patching of ruts which May develop before the time for full repairs comes. The whole of the metal should be ready by May, when the southwest monsoon bursts and heavy rains may be expected. About this time the first annual clearing of surface and drains is undertaken. The scraping of grass or cutting away of jungle merely for appearance sake is strictly forbidden, but anything that impedes the free discharge of rainwater from the road is removed and the side drains are cleared of silt and vegetation. The edges of the road throughout its length are kept down below the level of the metaled surface, so that scupper drains, which are injurious, may be strictly prohibited. The metal being all broken and the rains having set in the repairs proceed at once.

If continuous ruts have developed, they are cut out to a width of 2 to 3 feet and a depth of a few inches; the old material so excavated is sifted and cleaned, the detritus due to the complete disintegration of the metal is thrown away, but the finer stone and unworn metal is retained as a blinding for the new material about to be laid. The rut is then carefully filled with new material, the blinding of old worn metal applied, and the consolidation by iron rollers of 35 cwts., drawn by one or more pairs of bullocks, proceeds. If the rains are not sufficiently lasting, water is collected in the side drains or led for long distances in the hill country and freely applied during the consolidating process. If the traffic has not developed continuous ruts the places that require repair are cut out in rectangular shapes and the process of repair is as above described. In some cases, and especially in towns, the whole surface is picked up annually and reformed and completed in a similar manner. A portion of the metal is reserved for a second repair later in the year when the second monsoon—that from the northeast—sets in, about October or November, when the rains receive their second clearing up.

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* Practically $8,000. † Practically $4,800.

Where this system is properly carried out the result is a road surface hard as adamant and smooth as a billiard table. The director of public works would be very glad, in the event of his visiting America, to afford the Department of State every information regarding the details of the road-maintenance system of Ceylon that bears his name. Tables are annexed showing the total number of miles of road open in Ceylon, metaled, graveled, and natural, the latter being merely tracks through the jungle, cleared of trees and roots but without culverts or bridges, and only passable for wheeled traffic in dry weather.

Diagrams are also appended showing the total expenditure on construction and upkeep for the past 6 years.

The average cost of maintenance per mile of all roads in charge of the public works department now is 314.80 rupees per mile per annum, or, in American money, $111.

The highest rate of expenditure on roads exposed to continuous and heavy traffic is 1,146.51 rupees per mile=$405. The lowest 17C rupees=$60.

R. K. MACBRIDE,
Director of Public Works.

COLOMBO, *Ceylon, July* 2, 1891.

Number of miles of road open in Ceylon.

Metaled roads	1,634.80
Graveled roads	965.44
Natural roads	541.90
Total	3,142.14

CHINA.

REPORT BY MINISTER DENBY.

Road making is an art, which, among the Chinese, has never been brought to any great perfection. It is remarkable that a people familiar, as they have been for centuries, with the essential part which roads play in commerce have never undertaken to improve the means of communication by land with their distant frontiers or between their great cities.

The explanation, probably, is that in the greater part of China proper there are water ways, natural and artificial, crossing the plains as a net, while human labor has always been found preferable to pack horses, or other beasts of burden, over narrow and circuitous mountain passes.

In southern China, at the centers of the tea trade, the long strings of coolies bearing down from the hills their fragrant burdens of tea leaves in deep baskets slung on poles is a familiar sight. The transport of brick-tea over the mountain roads of Szu-chuan into Thibet, a trade said to amount to £200,000 annually, is also effected by coolies, who here, on account of the steepness of the defiles, do not use carrying poles, but bear the tea on a wooden frame strapped to their shoulders. In this way they make a 15 days' journey over mountain paths of great difficulty, bearing about 100 pounds of tea each, for which service they receive the equivalent of from $3 to $4.

The importance of military roads has never been thoroughly impressed on the Chinese. The great campaigns of the Mongol and Manchu emperors were conducted with hordes of nomadio cavalry, whose movements were independent of fixed routes. It was the terrible Mongol horsemen who, in the thirteenth century, overran Asia, a resistless wave of barbarism, threatening even the kingdoms of Christendom. In the eighteenth century the Manchu conqueror's campaigns against the Mohammedans of Shi and Kashgaria were also conducted chiefly by mounted troops. In none of the wars of China has she yet faced the problem of the transportation of heavy ordnance.

In northern China, where water ways are not so numerous as in the south, intercommunication has always presented serious difficulties which no attempt has been made to overcome. Bridges have been built over some smaller streams, but are not kept in repair. The large rivers are to be crossed by ferries only, the smaller to be forded. At the ferries the ferry-boats are intentionally constructed with a high side-board so that the carts cannot be driven on without unhitching. This gives employment to a crowd of hangers-on, in unhitching and lifting on and off the carts, for a compensation. The other arrangements of the highways seem dictated by a similar motive. At some places there are bridges which are too narrow to be crossed by carts, where the mules are taken out and led over singly while the carts are carried over on men's shoulders. In time of flood there is frequently no way of crossing at all. Where nature has afforded no convenient impediment, bad characters sometimes dig holes in the road in order to obtain employment in helping carts through.

The roads themselves, outside the cities, are merely a line of ruts across the fields. In winter when free from rain, as they are for nine months in the year, they keep in very good condition. In summer they are a fathomless impassable bog, and travel except on foot is suspended. Inside the cities some of the most crowded thoroughfares are paved with massive blocks of stone. Where kept in repair these stone roads are serviceable, but they are so infrequent as only to accentuate the impassability of the others.

The importance of the rapid conveyance of intelligence to the center of government from the outside provinces has always been felt. In the days preceding the introduction of the telegraph this was accomplished by an elaborate system of post stations. These were placed some 30 miles apart and relays of horses constantly kept in readiness for the imperial courier. By these means dispatches have been sent to distant provincial capitals at the rate of 250 miles per day. This system was brought to great perfection under the Mongol emperors, if we may trust the description of Marco Polo. He states that Kublai Kahn had 300,000 horses, especially kept for the use of messengers, and more than 10,000 post stations. In connection with the mounted couriers an elaborate system of foot messengers was also maintained. The stations for the

runners were only 3 miles apart, and by them the Emperor is said to have received news from places 10 day's distant in 1 day and 1 night, or, if need be, news from 100 days off in 10 days and nights, "and that," to use Marco Polo's own words, "is no small matter."

Fruit gathered in Peking in the morning was thus transmitted to the summer palace, 10 days distant, arriving the evening of the next day.

A cruel custom prevails with reference to the official courier service in Thibet. The express courier from Gartok to Lhara, a distance of 800 miles, travels night and day. He is not relieved en route. His clothes are sealed onto him and can only be removed after the seal has been broken by the proper official. These messengers are lifted at the post stations from one horse to another and arrive at their destination with cracked faces and eyes bloodshot and sunken. They sometimes die on the way from exposure and fatigue.

The elaborate system of posts for imperial messages in China seems never to have suggested the establishment of a government postal service for the public at large. In spite of its autocratic and centralized character, the conveyance of the people's correspondence has never been considered a proper function of the government. All private correspondence is transmitted by private post-offices, or "hsin chii," of which there are several rival establishments in each city. These firms employ their own couriers, who travel by horseback or on foot or, where possible, by steamer. Speed is not a conspicuous feature of the system, though between cities where the business justifies a regular mounted service, letters and small parcels are carried at the rate of 75 or 80 miles a day. The charges for small distances are not excessive, a letter being sent from Peking to Tientsin for about 10 cents. For long distances, however, the charges are disproportionately large. This legation finds frequent occasion to use the private post for communicating with missionaries in the interior, particularly in Shantung. From Peking to Chinanfu, the capital of Shantung, is about 225 miles, and the usual charge for transmitting a letter thither is 40 cents.

One peculiarity about these postal establishments is their responsibility for loss or failure to deliver. Competition forces them to be thoroughly reliable and careful. At river ports at the hour of sailing of a steamer, the competition between rival firms in soliciting patronage through their runners is said to be a familiar incident.

That these systems of government and private posts should exist without leading to the construction of proper post roads and highways is remarkable. Over some mountain roads, however, which would otherwise be impassable, considerable work has been done and money expended. In some places the paths over the passes have been simply paved for foot travelers, but in others provision has been made for the passage of carts. Most of these roads date from great antiquity, but there are occasional instances of recent construction and repair.

The most important of recent improvements is the putting in order

of the road through the Chii Yung Kuan north of Peking. This is the pass leading into Mongolia from China, through the great wall, past the cities of Naukou and Kalgan. It is familiar to all tourists to Peking as the "Naukou Pass." The work of repair here was undertaken by the viceroy Li Kung-chang some years ago, and in the Peking Gazette of the 19th of May, appears a memorial from him announcing its completion. I inclose this memorial at length, to which I call attention, not only for its reference to the subject of this dispatch, but as illustrating a peculiar feature of Chinese government.

The system of intrusting important public works to the "gentry and literati" is not new in this country. Private subscription to public works such as road making, river embankment, public charities, etc., form an important resource of the treasury. The proposed plan of lending out the public funds to pawnbrokers is a thoroughly Chinese proceeding. The deriving of Government income from money loaned at interest to its subjects prevails extensively here, though the income is always, as in this instance, devoted to a particular purpose. Gentry who distinguish themselves by large subscriptions or by exertions in the public service are rewarded by tablets and arches or by the bestowal of honorary official titles.

The road whose completion the viceroy reports is said by recent travellers to be of the most creditable character. Drains have been made, substantial bridges built, inequalities leveled and obstructing rock hewn away. The new road will be of great benefit to local traffic but particularly for the transport of the immense quantities of tea shipped by Russian merchants, on camels, from Tungchou to Kiachta, via this pass.

CHARLES DENBY,
Minister.

UNITED STATES LEGATION,
Peking, June 7, 1891.

ROAD REPAIRING IN CHINA.

[Translated from the Peking Gazette of May 19, 1891, by Ch. Denby, jr., second secretary.]

Li Kung-chang, earl of the first rank, grand secretary, viceroy of Chihli, presents a memorial with reference to the completion of the work of repairing the road through the Chii Yung Kuan, the important thoroughfare north of Peking; he requests the gracious granting of rewards to those gentry who have exerted their efforts in the work. A respectful memorial on which the sacred glance is humbly entreated. Memorialist represents that Chii Yung Kuan in Yen Ching Chou is the first of the nine important places in Tai-Lsing. It is close to the capital. Such are its cliffs and abrupt hills that a step can scarcely be taken without danger. Former dynasties looked upon it as an important place for the protection of their frontiers. This dynasty, however, has borders widely extended. Those without and those within the pass are of one family. This road must be used by the princes of the inner and the outer Mongols bringing tribute in their journeys to and from Peking. It is used also for

the transport of military supplies for the forts on the frontiers of the two circuits of the northwest. This pass has not been repaired to any extent for more than two hundred and some score years. For 45 li the road pierces the hills and winds through gorges, where in summer and autumn water and stones dash downward, so that travelers go through with difficulty. In winter the streams in the gorges freeze to solid ice and many men and animals fall. The merchants regarded the road as a dangerous one. An urgent necessity existed to devise means for the repair of it for the public good. The amount of work to be done, however, was excessive and the funds required very large, and Chihli has long been a province deficient in revenue, whose public treasury could make no appropriation for this purpose.

In the fourth moon of the thirteenth year of Kuanghsii (1887), Chang Hung-chün formerly prefect of Hsüan Hua Fu, together with Chang Chéng-i, deputy magistrate of Yen Ching Chou, and Ho Chéng-hsii, district magistrate of the Huai-lai district, made inquiries as to the opinion of the elders and gentry and the views of the people in general, who all expressed themselves as of the opinion that a tax should be levied on cattle and beasts of burden passing to and fro to raise funds to put the road in order. In this arrangement the merchants at large rejoicingly acquiesced. It was accordingly decided to place a public office in the Chii Yung Kuan and levy from camels, mules, cattles, horses, donkeys, pigs, and sheep a charge of from 10 cast (2 cents) to 2 or 3 cast each, to be exacted of all alike whether coming into China or going outward.

Thus, from an expense inconsiderable to the merchants and people at large, was created a revenue to be relied on forever by the locality. The affair was easily started.

Those who bring down government horses and return empty handed, women riding, unaccompanied by goods, and agricultural laborers gathering fuel and grass to be carried away on beasts of burden, are not required to pay anything, in order to show that proper discretion is exercised.

Li Hou-chi and other upright men from the literati of the locality have been selected and intrusted with the management of the work. They have agreed upon regulations which were submitted by petition to memorialist who authorized their provisional operation.

The magistrates of the several departments concerned repeatedly surveyed the said pass. From the eastern postal station at Chá-tao to Lang Chfao (Wolf Bridge) at Chang Ping Chou, it measures in all 6,730 chang (about 4,200 rods). The estimated quantity of earth and rock to be moved and the labor to be expended was very great. As the funds were to be derived from animals coming by at intervals, it was impossible to undertake the whole whole work at once. Hence the distance was divided into eleven sections to be put in order in succession. Work was begun at Pa-ta-ling and elsewhere which are the most dangerous localities.

At this time it happened that Hu Tung, a native of Yen Ching Chou, now an expectant taotai in Hupei, had returned to his native place and memorialist, inasmuch as he was thoroughly acquainted with the topography of the pass, ordered him to associate with the magistrates of the departments concerned in their consultations and undertakings.

At present, the road through the pass having been leveled by degrees, the number of carts passing through daily increases and memorialist, being petitioned, authorized the levy of a fee from them as from animals to be devoted likewise to the work of repair.

The officials and gentry concerned in the work made a thorough examination of the features of the locality and ascertained where dikes must be built, drains dug, holes filled, elevations leveled, and where land should be bought from the people to make a detour, and where the road should be carried along a hillside to make a thoroughfare. The road has been made 45 chang (450 feet) to 1 chang (10 feet) or 2 chang (20 feet) broad, differing in different places. The sections of the road have

been successively repaired, diked, and leveled so that carts even now traverse it without danger or obstruction.

If it is intended that the work shall endure it can not be completed in one day. Whenever a heavy rain falls the water rushes down from the peaks with myriads of stones, as if heaven were being dragged down and earth uplifted. If these stones become jammed together the road overflows to great depth and there is no thoroughfare through the gorges. The causes of these defects must be ascertained and remedies sought therefor that control may be established.

During the summer of last year there suddenly came on a continuous rain which lasted many days and was heavier than for scores of years. The part of the road first repaired, that at Pa-ta-ling, which was called the Tien Ksien, though it encountered this terrible flood still remained unhurt. Other places were slightly damaged, but were easily repaired. At Tan Chin Gorge and at the Buddha's Stone Shrine the hills on both sides crowd together and leave no space to carry off the water. Here the abutments of the road were half washed away. Man's strength is inadequate, in view of the circumstances, to avoid such mishaps. It was therefore decided to change the road to the west side and make a circuit around these two places. The main road will be reëntered again at Lin Lang Ting. By avoiding watery places and following mountain paths, by making earth roads and keeping out of the way of rocks, it is hoped that future damage will be escaped. This suggestion being made by those in charge of the work they were ordered to take action accordingly, and, on the 18th day of the second moon of this year, they reported the completion of the work.

Orders were given to send Wang Shou-cheng, prefect of Hsüan Hua to inspect the part of the road which has been leveled, and it is found that merchants going north and south have been greatly benefited. There is, however, no work which will not deteriorate with lapse of time. The road through the pass will be trampled and worn by horses and carts and eroded by wind and rain. Unless means are devised to provide funds for the important repairs it is to be feared that after some years the labor and hardship which have been spent upon this work will be found to have been in vain.

The total receipts from animals from the middle of 1887 to the beginning of 1891, have been 29,160 strings of cash (about $25,000). The merchants of the vicinity subscribed also 600 taels of silver. Over and above what has been expended there remain only 3,500 strings of cast and 600 taels. This sum is insufficient. The tax on animals must be retained for several years, not only to defray the incidental repairs, but to collect the sum of 10,000 taels, upon which the toll will cease. The income from the cart tax commenced after the beginning of the work on the road, and when the tax on animals is abolished the tax on large carts must be retained several years. This also will stop when 5,000 taels have been raised. The two above sums will be kept apart and loaned to merchants to produce interest. The interest from the tax on animals will be used only for annual repairs; that from the sum collected on carts for the expenses of great repairs. Regulations will be enacted establishing a mutual supervision between gentry and officials to prevent unlawful usurpation, waste, deficit and misappropriation.

Progress will hereafter be made in the art of road repairing, and every day the road will improve so that for scores of years it will cause no anxiety. All rejoice that a dangerous way has been made smooth.

The gentry engaged in the affair have relied upon their own resources in effecting the repairs, having made no perquisites whatever. Through 5 years they struggled against hardships diligently, accomplishing a difficult task. Now it has been brought about that a pass, in which a horse could scarcely place a foot, has been transformed into a level road, over which loaded carts easily travel. This manifests the credit of those intrusted with the work. They are really deserving of praise, and it is proper to recommend the more meritorious for reward.

AMOY.*

REPORT BY EDWARD BEDLOE.

INTRODUCTORY AND EXPLANATORY.

Road making as an art involves at least five factors: First, the nature of the materials employed or local lithology; second, the topography of the country traversed; third, the geology of the country traversed; fourth, the climatology of the country traversed; and fifth, the system employed by the roadmakers.

All of these vary from point to point, so that in no two places do the same conditions prevail. It is well to bear this fact in mind, as one accustomed to a kind of work perfectly suited to the locality to which he belongs is very apt to misjudge work perfectly suited to another locality with whose circumstances he is unfamiliar. The roads of Amoy are very different in many respects from those which prevail over the larger part of the United States, but they are admirably adapted to the conditions imposed by the five factors enumerated. To understand the first thoroughly it is necessary to understand the last.

On account of the facts hereinafter set forth there is no difference between city streets and country roads in Amoy. All are made of the same materials, in the same way, and under the same law. If streets are to be taken as those complex institutions, so familiar to Americans, which serve as thoroughfares, water conduits, sewer, water, gas, and electrical ways, there are none such in Amoy. There is no difference between the most crowded city district and the lonely cemetery in this particular regard, excepting that the roads are less worn in the latter than the former neighborhood.

LITHOLOGY OF AMOY.

The only rock formation in Kulangsu and the chief one in Amoy is granite. Where it has not been acted upon by the elements, it is a hard, handsome stone resembling Quincy granite, but neither so strong nor so durable. It is seldom quarried on Kulangsu, what cut stone is used there being brought from other parts of Amoy.

The elements act upon the granite in different ways. The commonest is where the rock has been corroded until it has become a nodular hard-pan. This represents two-thirds of the surface of Amoy. It is too tough to be taken up with the spade or shovel, but offers practically no resistance to the pick or crowbar. In this condition, as in fact in all others, where it has been greatly weathered, it is very porous, as is shown at every rainfall when the water instead of collecting on the surface, percolates downward many feet, if not yards. It has little filter-

* Consul Bedloe acknowledges his obligations to the following gentlemen for assistance rendered in the preparation of this report: Francis Cass, William S. Fales, H. E. Howard, K. Ping, and John H. Coombs.

ing power, less than sand, and much less than sandstone or magnesium limestone.

At the United States consulate, a large amount of slaked lime was used as a fertilizer upon the garden and grounds. The rain took up considerable quantities of lime in both solution and suspension and carried these downward at least 80 feet below the surface into the well on the premises. The water of that well has been calciferous ever since.

At Dakin's pharmacy the well, though thoroughly cemented, shows the permeability of the decayed granite in which it is sunk by a very perceptible osmosis of salt water from the bay whenever the dry season sets in and the water in the well sinks below the level of the sea.

The well at the London missionary establishment shows traces of drainage from the Chinese quarter in that neighborhood.

A well near the go-down of F. C. Brown & Co. shows that it receives an appreciable amount of petroleum compounds and lixiviation products from the go-downs and thoroughfares of that vicinity.

The water of the well below the cemetery at Lam-paw-do contains lime from the white wash of the numberless graves there, and probably small quantities of organic matter from the interred bodies.

The third stage of the decomposition of granite is marked by a coarse gritty sand and by beds of clay. Of the former there is any amount, and of the latter large quanties in the bed of the harbor. Anyone who will take the trouble to examine the land between high and low water mark will find it clearly divided into two belts. The upper, or one nearer the shore, is granite sand, and the lower clayey mud. By digging through the former clay will be found at every point. The fact is utilized at Chich-Boe where the Chinese use this clay to make fine tiles and terra cotta.

The three stages described are general; between them are any number of intermediate ones. In fact as an entire series from the virginal rock, at one extreme, to the coarse sand and clay at the other may be found at many places in Amoy.

There is no limestone in the immediate vicinity of Amoy. The lime used in the various industries is made by burning oyster, clam, and other molluscan shells, or else imported from other districts.

Cement rock does not occur in Fuh-Kien so far as is known. What is consumed is imported. Formerly nearly, if not quite all came from Europe. In the past 20 years inexhaustible supplies of first-class quality have been found in the British, Dutch, and Spanish East Indies, and these now control the market.

Besides the granite sand described, there is a fair grade of ordinary sand along the beach, made out of the former by the triturating action of the waves.

There is little or no gravel, shingle, or shards.

Of the artificial stones, those made from clay largely preponderate These are used in road making, as are also fragments of crockery, earthenware, mortar, cement, and shells.

TOPOGRAPHY.

The surface of Amoy, its adjacent islands, and the surrounding country is very rocky and uneven. Summed up in a few words, it consists of ranges of granite hills and mountains varying from 1,000 to 1,800 feet in height, with the intervening space filled in with subhills, huge bowlders, and small alluvial plains. A rough estimate would divide the surface of the territory as follows:

	Per cent.
Mountains whose slope is more than 45°	20
Mountains whose slope is less than 45°	15
Hills	30
Bowlders	5
Plains	30

The mountain ranges are continuous, with irregular outlines rather than saw-like, as with the Sierra Nevada of the North American continent. They are dotted and at places half covered with bowlders.

The roads follow the plains as far as possible, skirt the sides of the hills and mountains, and in many cases go over the hills instead of making a detour around them. This occasionally necessitates very sharp gradients and renders the use of carts, wagons, and carriages impracticable if not impossible. Even the employment of rickshows (jin-rik-i-shas) is attended with danger.

The tides are very high (21 feet 6 inches in the spring), so much so that although there is a very wide beach between low and high water mark it can not be used for travel. At high water the sea reaches the hillside, and at low water the beach is too soft and oozy for either pedestrian or equestrian purposes.

GEOLOGY.

The island of Amoy and its neighbors, including Kulangsu and Little Quemoy, are portions of a rocky and uneven territory, containing few small plane surfaces, which, prior to the glacial epoch must have extended from the foot walls of the mountain range (of which Lam-tai-bu, 1,180 feet altitude, is the leading peak) to Quemoy, and probably reached further out into the Formosa channel.

The islets of Wu-seu and Quemoy-spit are undoubted relics of what was once a much larger expanse of land.

Prior to the glacial period the country must have been more fertile than it is to-day, owing to the possession of a larger amount of superjacent soil. Much of it was like the arable belt along the southwest edge of Kulangsu. It supported a large vegetable life, as is evidenced by traces of lignite and carbonaceous soil at every point where the mountain slopes have prevented the erosion of the soil by the movement of the glaciers in the far past.

Several excavations made for funeral and architectural purposes have encountered thin beds of carbonaceous soil beneath the hard pan which constitutes so large a portion of the present surface.

The fauna of that period were apparently more numerous than those of to-day, and included deer, goats, pigs, buffaloes, tigers, leopards, monkeys, cave-tigers, cave-bears, cave-wolves, jackals, wolves, and bears. There seem to have been alligators, boa constrictors, and elephants, but this is not yet certain.

There are evidences of prehistoric man in shell mounds, and in ashes and bones, in caverns, and also in implements of stone.

The glacial epoch must have been of short duration, as there is an absence of sand, shingle, and gravel, very remarkable. There is of course a very large moraine beneath the Formosa channel, and small ones near Chiang-Chiu, Chloh-Jim, Lian-Ho, and other points. On the other hand there was a large transportation of bowlders by the glaciers from Peh-phang-nia-teng, Him-sek-poa, and the mountainous districts of the north and northwest, and their deposition at every point between the mountains mentioned and the low-water mark beyond. The great blocks of stone are found on every mountain and below the surface of the water to a depth of at least 10 fathoms.

Of the bowlders scattered over Kulangsu the majority are a granite, resembling syenite, but numbers consists of gneissic granite, diorite, delorite, graphic granite, auriferous quartz, and sometimes, though rarely, of semi-micaceous schist, carboniferous limestone and sandstone.

The auriferous quartz indicates the presence of gold not more than 150 miles from Amoy, and the carboniferous rocks of coal measures much nearer the coast.

The lithologic variety shows that glaciers which found their embouchement about Amoy must have reached at least 100 miles from the coast up into the interior of Fuh-Kien. The height of these glaciers, or this glacier, for in all probability the land was covered by one unbroken sheet of ice for leagues and leagues, is hard to determine.

Glacial scratchings are found at every point on Kulangsu and Amoy and even on the summit of Lam-tai-bu. The glacier therefore which once covered the district must have been over 1,180 feet thick. If we are to judge by analogy and use Lyell's researches in Great Britain and Tyndall's in the Alps as our guide in estimating its dimensions the Amoy glacier was from half a mile to 1 mile thick, and in its full career covered the Formosa Channel and all of the Island of Formosa excepting a few high peaks. It reached far out into the Pacific Ocean, extending in every probability beyond the axis of the Botel-Tobago Archipelago.

The paucity of moraines and the wealth of bowlders indicate that the glacial epoch terminated very suddenly so far as Amoy is concerned. A glacier dies from one of two causes; either there is an increase of temperature too great for the continued existence of ice or there is a large decrease in the supply of the water which in congealed form goes to make it up. Sometimes the two causes combine and make one. When the decrease of a glacier is slow there is a large deposition of

gravel, sand, and earth along with bowlders. When it is rapid there are bowlders and comparatively little gravel, sand, or earth. As there are little soil, few moraines, and many bowlders on Kulangsu and Amoy it is probable that both causes mentioned united in this instance and that the great glacier retreated suddenly and rapidly from its maximum development back to the mountain chains in the interior of Fuh-Kien. No other hypothesis can be framed which will satisfactorily explain the present topographic and lithologic condition of the neighborhood and its surrounding territory.

The rocks mentioned indicate that there has never been any volcano nor volcanic action in the immediate neighborhood of Amoy. A few diorite bowlders with lava-filled veins prove that to the north or northwest there is a district which at one time was the scene of tremendous volcanic activity.

The absence of seams, faults, or crevasses is evidence that there have never been any serious earthquakes in Amoy, except it may be the dying tremor of some seismic convulsion many miles away. We are also led to the inference that there never will be a volcano or an earthquake near Amoy so long as the present coast line remains unchanged in its general features.

This theoretic view is confirmed by the fact that all the Chinese accounts and traditions of earthquakes locate them in the far south towards the Malay peninsula, the far west in the district of Sz-Chuen, or the territory bordering on the mountains of Quin-Lun and the extreme northeast, where, at some period not very distant, there was considerable volcanic and seismic action.

The absence of all stratification, the weathering of the granite, and the non-existence of fossils, Tertiary or Post-tertiary, in or upon the rocks above a plane 10 feet above spring high-water mark show that this part of the coast of China has been exempt from the processes of submergence and upheaval which have been so common in the geologic history of other lands. As Kulangsu looks to-day it looked many thousand years ago, except that it was greener and prettier then and a trifle more picturesque. It was the same, but more rocky, ragged, and forbidding when neither the Alps, Apennines, Himalayas, Rockies or Andes had been born. It is as old as the Apalachian range of North America and the Norwegian headlands, the two oldest monuments of the slow development of the great globe we live upon.

The weathering of the granite of Amoy is something phenomenal. At points the solid rock has been disintegrated 50 and 60 feet vertically. The breaking down has been confined to the feldspar, although both the mica and hornblende have been affected. Of the different kinds of feldspar the orthoclase shows the greatest decay, with the heteroclase a close second. Near the sea this disintegration has been of no benefit to human or vegetable life. The potash, soda, and lime salts, the clay and other valuable products of the decomposition of granite have run into the sea and been lost. In the interior country the alka-

line salts named have been absorbed by the soil and are valued fertilizers. The clay accumulates, forms beds, and is in the after years utilized for bricks, tiles, chinaware, and terra cotta. The chief advantages of disintegrated granite are that it makes good roads or country pathways and excellent walks or paths in the garden. Mixed with lime it makes a good mortar, and with cement a very good concrete.

CLIMATE.

Amoy lies in 24° 40′ north latitude and is just outside of the tropics. It has practically but two seasons, the wet and dry. The former begins in February and closes in June and is about 4 months long; the latter constitutes the remainder of the year.

The annual rainfall is about 46 inches, which fall in 445 hours in 100 days. It descends in large quantities in a short time, and owing to the topography exerts a powerful erosive action, producing gulleys in the thoroughfares and deep channels at the foothills.

The temperature varies from a maximum of 95° F. in July to a minimum of 40° in March. Its annual mean is 70°.7 F., making the isotherm of Amoy the same as that of the Pacific coast of the lower part of California.

The barometer is subject to great fluctuations, especially during typhoons. Its annual mean is 30.095, almost the isobare of Mobile, Ala., and Jacksonville, Fla.

The hygrometer varies from 95 maximum to 10 minimum and has an annual mean of 28, making it a very dry climate.

The atmosphere of Amoy is seldom without good winds. The northeast monsoon blows almost continuously at the average rate of 10 miles per hour from September to April, and the southwest monsoon at the average rate of 8 miles per hour from April to September.

Besides these there is a local west wind from the mountains from about 4 a. m. to noon, attaining a maximum at 9 a. m., and a local east wind from the ocean from about 4 p. m. to 10 p. m., attaining a maximum at about 7:30 p. m.

A meteorological abstract for the year 1890 is as follows:

	Barometer.				Thermometer.			
	Maximum.	Minimum.	Mean maximum.	Mean minimum.	Maximum.	Minimum.	Mean maximum.	Mean minimum.
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*	
January	30.35	30.02	30.40	30.25	70	48	62	54
February	30.36	29.80	30.34	30.17	75	51	64	57
March	30.60	30.01	30.31	30.16	75	48	60	55
April	30.26	30.01	30.18	30.06	82	55	71	65
May	30.18	29.86	30.08	30.00	82	66	77	71
June	30.16	29.90	30.04	29.94	87	70	82	78
July	30.10	29.58	29.92	29.82	94	76	86	81
August	30.08	29.75	29.97	29.74	89	77	86	80
September	30.10	29.76	30.02	29.94	90	73	85	78
October	29.85	30.29	30.01	29.96	89	80	80	65
November	30.41	30.09	30.32	30.20	75	66	74	58
December	30.43	30.02	30.28	30.17	73	51	68	61

	Solar radiation.			Weather.			
	Maximum.	Minimum.	Mean.	Days rainy.	Hours of rain.	Rain in inches.	Days foggy.
January	132	65	110	9	74½	2.01	1
February	152	76	120	7	14¾	1.14	5
March	141	57	100	20	103¼	9.25	3
April	148	69	125	4	27	1.23	11
May	154	92	131	11	56¼	3.27	2
June	154	91	136	17	78¼	9.83	
July	156	130	149	10	23	7.90	
August	157	141	150	12	13½	4.03	
September	155	93	144	8	14½	0.66	
October	148	126	137				
November	133	113	132		3¾	4.27	
December	156	65	110	1½	36	2.01	
Total				99½	444¾	45.60	22

ROAD MAKING.

The roads in and around Amoy are admirable and are kept it splendid condition; when the ground is hilly, they are cut from the hillside; when the ground is level they are built up.

They vary from 20 to 30 feet in width and rise in the center about a foot above the level of the edges. Where the ground slopes, the rise increases in proportion in order to prevent the rains washing away the center of the roadway and the edges are guttered or ditched.

The main road of Amoy is 30 miles and the smaller roads and streets aggregate 150 miles in length.

In making roads on level surfaces a foundation of broken granite is loosely laid with a gentle slope upward toward the center; on this is laid smaller pieces of granite, broken brick and earthenware, and sometimes shells; on this in turn is put a mixture of granite-sand, clay, and lime. The road is sometimes rolled, but usually is battered down with hammers. The top mixture is applied wet and sets in 24 hours. Its composition varies as will be seen by the following instances:

No.	Sand.	Clay.	Lime.
1	5	5	1
2	10	3	1
3	4	2	1
4	10	4	1
5	5	4	2

In making it the sand, lime, and a little clay are mixed with water in a brown mortar and applied to the road; after the application and before it sets the remaining clay is thrown upon the surface and hammered down. There seems no particular rule as to the amount of top mixture to the square of road. It runs as low as 75 catties and as high as 175 to the square yard (100 pounds to 233 pounds).

The second layer runs from 1 to 4 inches in thickness, and the lowest from 6 inches to a foot.

The prices per diem paid for labor, etc., are as follows:

Quarry men	$0.25
Stone-breakers	.15
Stone-helpers	.10
Diggers	.20
Carriers (who carry 75 pounds to a load)	.20
Rammers	.20
Foremen	.30

The crude stone costs nothing, as farmers and others are only too glad to have the rocks and bowlders taken away from their land. Clay costs nothing when it is taken from the common land; when bought from private parties it costs from 1 to 5 cents a picul (135 pounds).

Common lime (the cheapest and most impure is used for the purpose) commands anywhere from 3 to 25 cents a picul.

The amount of labor performed by a Chinese coolie is much less than that by a Caucasion, and is seldom more than one-half. He never gets drunk, never strikes, and works on Sunday as on week days.

The cost of making a road is about $1 (Mexican), or 77 cents (American) per square yard.

The Chinese law requires roads to be kept in good order. The responsibility is put upon the headman of a village, the owners of the adjacent property, and the shopkeepers whose premises abut upon the thoroughfares.

In conclusion, it may be stated that the roads and wacks of Amoy are excellent and on a par with the best in the United States.

EDWARD BEDLOE,
Consul.

UNITED STATES CONSULATE,
Amoy, March 16, 1891.

FOOCHOW.

REPORT BY CONSUL GRACEY.

There are no roads in this part of China. The streets of Foochow are from 6 to 12 feet wide, many of them covered with stone slabs which are filthy beyond description, and are perfectly execrable.

We have no wheeled vehicles, and, as a consequence merely footpaths all through the country.

SAMUEL L. GRACEY,
Consul.

UNITED STATES CONSULATE.
Foochow, January 17, 1891.

HONGKONG.

REPORT BY CONSUL SIMONS.

In reply to your circular of November 8, 1890, I have instituted inquiries concerning street and roadway construction in Hongkong with the result given below in a letter from the surveyor-general.

In reply to inquiries contained in your letter of the 12th instant I have the honor to give below a description and cost of the principal forms of road construction adopted in the city of Victoria. As there is comparatively little carriage traffic, and the main wear and tear are caused by the numerous jinrickshas, we are able to adopt a much lighter form of construction than would be required if we had to provide for the yassage of heavy vehicles.

1. Macadamized roadway, formed of 3 inches in thickness of granite, broken to 2½-inch cubes, with a top dressing of granite broken to 1-inch cubes, blinding of decomposed granite, costs per superficial yard 18 cents.

2. Concrete roadway formed of a layer of concrete 4 inches thick, composed as follows: 9 parts of granite broken to 1-inch cubes, 3 parts shell lime and 2 parts red earth, costs 32 cents per superficial yard.

The macadam is adopted generally on the level roads and those of moderate gradients.

The concreted roadway is found well suited to the very steep roads running at right angles to the sea up the hillsides in the direction of the peak.

So far as technical knowledge of the subject is concerned I can add nothing to the foregoing. Notwithstanding the light character of the traffic over streets and roads so constructed they require considerable repairs, particularly during wet weather when the ground beneath softened by water no longer affords a firm support to the macadam which sinks in places forming depressions, these rapidly becoming ruts unless repaired.

The "heaving" effect of frost would, I believe, prove disastrous to streets so constructed while a loaded track would crush through the crust once the ground underneath become saturated with water. The streets and roads are considerably higher in the center than the gutters, which are made of cut stone.

With few exceptions no sidewalks are provided, pedestrians taking the middle of the street. Both streets and roads are kept in good repair and always scrupulously clean—one of the first things to attract the attention of visitors to Hong Kong.

O. H. SIMONS,
Consul.

UNITED STATES CONSULATE,
Hong Kong, January 20, 1891.

NINGPO.

STREETS.

The streets in the cities of this district, like those in all the rest of China, are poorly laid out, rarely exceeding 10 or 12 feet in width; they

are most generally paved with large slabs of granite, about 2 feet wide by 3 feet long and 4 inches thick; under these are sometimes drains. It is a difficult matter for a stranger to walk on these stones on a rainy day, as the constant friction from the straw and wooden shoes of the natives has made them very slippery, while not wearing them smooth. The streets are kept in repair by the subscriptions of the gentry. It would be next to impossible for a handcart to pass through these cities, on account of the narrowness and crookedness of the streets.

COUNTRY ROADS.

The roads in the country are mere paths, averaging 4 feet wide, and are sometimes paved with round stones, at other times with slabs, by simply laying them on the top of the earth; at intervals a shed is built over the path, wherein a traveler can rest sheltered from the rays of the sun. These are called "rest houses." Now and then a square stone about 4 feet high and perhaps a foot square is seen close to the road; the traveler weary with his load places his back to this stone and lets his load down onto this stone and rests awhile, and when he is ready to renew his journey he does not have to pick up his load from the ground, but simply from this resting post. All roads, country and city, are built and kept in repair by subscription. There are no laws or regulations relating to roads, and the Government does not give a dollar towards their maintenance. There is not a wheeled vehicle of any kind in this vast district of nearly 40,000 square miles; everything is either carried on the backs of men or in boats through the canals. The roads in this district are the canals, which intersect every quarter, and one can travel in almost every direction for hundreds of miles by these canals.

JOHN FOWLER,
Consul.

UNITED STATES CONSULATE,
Ningpo, February 3, 1891.

SHANGHAI.

REPORT BY CONSUL-GENERAL LEONARD.

There are none but the most primitive and unimproved roads and streets in China, except in the few foreign settlements at the treaty ports, and there they are generally excellent, being constructed the same as in England.

Nearly all the travel and traffic of China is carried on by the rivers, and the canals, which have been built only a few miles apart all over the settled portions of the country.

The roads are but little used by travelers and wheeled vehicles as lit-

tle as possible, most of the land travel being in chairs carried by coolies, or wheelbarrows, which are used both for goods and passengers.

J. A. LEONARD,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Shanghai, January 12, 1891.

JAPAN.

REPORT BY VICE-CONSUL-GENERAL SCIDMORE, OF KANAGAWA.

The subject of scientific road building in Japan is a matter that has only of recent years received attention.

Previous to the opening of the country to foreign intercourse nearly all of the inland travel and carrying was confined to the backs of coolies and pack horses, and in spite of the introduction of railways and jinrikishas such is, to a very great extent, still the case.

Macadamizing is followed in the streets of the larger cities, but the work is generally of inferior quality.

In the country some of the main roads are fairly well kept, but the general rule is to repair the highways with loose earth, which naturally renders them execrable in bad weather.

The maintenance of these roads is at the cost of the local village or district authorities from taxes levied specially for the purpose.

G. W. SCIDMORE,
Vice-Consul-General.

UNITED STATES CONSULATE-GENERAL,
Kanagawa, Japan, January 28, 1891.

PHILIPPINE ISLANDS.

REPORT BY CONSUL WEBB, OF MANILA.

INTRODUCTORY REMARKS.

There is little or nothing to be said of the streets and roadways of the Philippine Islands that can possibly be of any practical value to the people of the United States, except in so far as it may serve as an illustration of the sad and demoralizing effects of neglect and indifference. It has been said that the cities and towns of this archipelago are at least a hundred years behind the rear guard in the procession of progress, and one who travels over the streets and roads of the country can hardly fail to become impressed with the truth of the assertion. There is apparently no incentive to improvement and no disposition to do anything more for the country than is absolutely

necessary for the comfort and convenience of the foreign residents who very rarely expect to remain here longer than 5 years. Probably it is this transient, ever-changing character of the foreign colony that may be taken to account for the fact that there is not a single driveway beyond the city limits of Manila, Iloilo, or Cebu, nor a roadway which will allow the passage of a four-wheeled vehicle with any degree of comfort to its passengers or of safety to its integrity. The Spanish officials who come here rarely, if ever, remain longer than 3 years, and the average term of service of the English and German merchant and clerk is 5 years; therefore the material development and permanent improvement of the country is left to the natives, who fail to appreciate the necessity of improved streets and roadways, and to the mestizos who do not feel disposed to develop the islands, knowing, as they do, that an advance in this regard must necessarily be followed by an increase of the already excessively burdensome taxes.

THE CITY STREETS.

The principal cities of the archipelago are Manila, Iloilo, and Cebu, and these are the only ones that have any of their streets paved. The principal business streets are paved with limestone blocks imported from China and laid upon a bed of gravel and sand. In Manila there is less than 2 miles of this pavement all told, and in Iloilo and Cebu possibly half that amount. All the other streets are macadam with a top dressing of sand and gravel, and ordinary dirt roads kept in comparatively good condition by throwing upon them dredgings from the ditches on either side.

The government assumes the responsibility of keeping the streets and roads in repair and fulfills the obligation by working upon them certain of the city prisoners who have been sentenced for slight offenses, such as failure to procure a "cedula personal," or identification card, or to have neglected to comply with some other civil regulation. The duty of street inspection and of making minor repairs is left with the native "bomberos," or firemen, but the wretched condition of most of the streets outside the business quarters indicates that they are not over zealous but are disposed to do barely more than enough to avoid censure from their superiors. There are half a dozen streets that are used by the foreign residents for evening drives, and these are kept in reasonably good condition through the efforts of the Spanish officials. They are made with a foundation of broken rock, over which gravel and sand from the river and estuaries are thrown. Buffalo carts are almost constantly in use for the purpose of hauling gravel and sand to these streets, and the unremitting repairs keep them in a state that admits of fast driving and comfortable riding.

There are no heavy drays in use, the heaviest vehicles being the two-wheeled buffalo carts and the pleasure carriages, which are mainly light victorias, broughams, and barouches.

Outside of the business centers and the districts occupied by foreign residents the streets are generally poorly kept dirt roads flanked by muddy ditches which, during the major portion of the year, are filled with stagnant, slime-covered water, which in any other country would be considered as extremely dangerous to the public health.

COUNTRY ROADS OR HIGHWAYS.

The great majority of the country roads are almost impassable during the rainy season, and are only traversed during the dry months by the light two-wheeled "carronatas" of the country, which are generally drawn by two horses. They are made by throwing up the dirt from the ditches along their sides, and in many places are so rough and uneven that riding in the carronatas is anything but comfortable. The passenger is jolted about in a most disagreeable manner and usually arrives at his journey's end with every muscle in his body bruised and aching as if he had been rolled down a rocky mountain side. In some cases he is obliged to leave the vehicle and walk half a mile or more while the horses struggle along with it through the sink holes and over the rocks and hummocks. At many points the road is merely a track worn by the carronatas over a level plain with no ditches at its sides and without evidence of repairs of any kind. No attempt is ever made to haul the produce of the provinces over these wretched roads and all that reaches the cities comes by water in barges and sloops.

The authorities of the various towns and villages are supposed to look after the repairing of the roads, but the condition of the latter is striking evidence of the indifference and neglect manifested in everything in the way of public improvements. In many of the provinces there is but one of these dirt roads, the main one used by travelers from town to town, but the country is traversed by numerous footpaths, over which the natives carry produce on their shoulders or heads. The major portion of the archipelago is practically an undeveloped wilderness.

ALEX. R. WEBB,
Consul.

UNITED STATES CONSULATE,
Manila, Philippine Islands, January 8, 1891.

TURKEY IN ASIA.

PALESTINE.

REPORT BY CONSUL GILLMAN, OF JERUSALEM.

STREETS.

The principal pavements made in Palestine are in the city of Jerusalem, and it is only within recent years that they have been constructed in accordance with anything like modern requirements. The superior and massive Roman pavements, over 2,000 years old, and still in fair preservation, are not here taken into consideration. They are, indeed, hidden from sight and use many feet beneath the rubbish of the city.

The material used for streets is stone cut to about the shape and size of ordinary brick, or a little larger; this is laid in sand, the long and narrow side up. No teaming is allowed over such a street. In the few streets where carriages are permitted to pass the center of the street is macadamized, only the sides being paved.

The stone used is generally the harder kind of the so-called Jerusalem marble, which is really only a species of limestone partially turned to marble. Of this there is a great variety, differing much in quality.

For the fully paved street the cost varies from $1 to $2 per square yard. The depth of the pavement rarely exceeds 6 inches. The foundation is almost invariably the rubbish of the ancient city, which has accumulated during centuries, and through its frequent destruction in sieges, etc.

Where streets are paved in Jerusalem at the present time, well-constructed stone sewers are always made beneath them. These are at various depths, according to the requirements of the case.

Many of the streets ascend steep hillsides. These are built in terraces, with steps; the rise of the steps or terrace being protected by a broad flagstone, set on end, at the level of the pavements. Of course, in such cases, teaming is out of the question, and they generally wear well.

HIGHWAYS.

The roadways built within late years in Palestine, and those in process of construction, are greatly superior to those formerly made under the Ottoman Government. At present they resemble good macadamized highways, properly graded, and in many cases provided with side drains. Where necessary, in crossing the more dangerous passes, stone parapets of mason work are built along the precipices. The material used for the roadbed is the ordinary limestone of the country, broken up into the usual cubes of the required size. This is covered with earth or gravel, which is finally leveled and smoothed by heavy stone rollers. The foundation varies, being commonly the stiff clay of

the country, though sometimes it is of sand or rock. Where the grade has to be considerably raised, large bowlders are rolled into place to form the foundation of the roadbed. The cost of such a road is from 80 cents to $1.30 per square yard.

REMARKS.

The methods and peculiar system followed here are not favorable to the best work, and can not be taken as a criterion for more civilized countries. A large part of the work is done through the enforced labor of the peasantry, which nominally costs nothing, and the materials lie adjacent to the roadway in unlimited abundance. The chief expenditure is for the superintendents, engineers, and overseers, of whom there is always a superabundance, ludicrously out of proportion to the requirements of the case.

As to the maintenance of streets and roadways, this is but seldom attended to in this country. Where a good road is made it soon falls into disrepair, through its being almost totally neglected.

The effect of improved roads upon land values and other economic conditions is as not as pronounced as it is in other lands. The camel is here the chief agent for transporting merchandise, and is largely used in all traffic. This does not necessitate a finished road. The introduction of carriages and wagons is comparatively a recent innovation, caused by the large influx of travelers and the establishment of foreign colonies.

HENRY GILLMAN,
Consul.

UNITED STATES CONSULATE.
Jerusalem, January 28, 1891.

SYRIA.

REPORT BY CONSUL BISSINGER, BEIRUT.

THE BEIRUT-DAMASCUS HIGHWAY.

It would hardly, perhaps, be expected that a report on "country roads or highways" in this far-off eastern country could be of any possible value, and yet Syria maintains at least one highway that will compare very favorably with any road in America or Europe, and a description of the same may therefore not be wholly without interest and perhaps even of some slight practical value. It is the carriage road from Beirut, on the Mediterranean, to Damascus, on the other side of the Lebanon Mountains, a distance of 113 kilometres or about 70⅝ miles, completed 1860.

CONSTRUCTION OF THE ROAD, ETC.

According to the statement of the officers of the company—for the highway is owned and operated by a private stock concern—the roadbed is made of a layer of macadam 20 centimetres in thickness, reposing upon a substructure of ordinary earthwork

This "macadam" is composed of a compact mass of calcareous pebbles of not more than 6 centimetres in diameter, spread over the substructure of earthwork in such a manner as to have gentle slope from the center of, say, 1:30; heavy metal rollers of about 5 metric tons, drawn by twelve mules, pass over and crush the pebbles, this making a smooth and even roadbed.

The cost of the material for metaling or ballasting is 1 franc 60 centimes (32 cents) the cubic metre, crushed, sifted, and measured, exclusive, however, of the cost of transportation, which is about 40 centimes (8 cents) the cubic metre.

Along that part of the road which passes over Mount Lebanon this material is extracted from quarries in close proximity to the road itself, and the cost of transportation is therefore insignificant; but in the plains and the Anti-Lebanon the calcareous banks are more scattered and the cost of transporting the material is considerably enhanced.

The roadbed is renewed on an average once in 3 years, and for this purpose the road is divided into three sections, one of which is remetaled every year; besides this, those parts of the road that are subject to an extra amount of wear and tear, like the approaches to Beirut and Damascus, are regularly watered during the dry season; that is to say, between the months of May and November, while the excessive dust that necessarily accumulates is removed from time to time with wooden scrapers. Ditches are running along both sides of the road, which are kept in good order to prevent the submersion of the roadbed, and when snow obstructs the highest and most exposed parts of the road in the Lebanon, it is cleared away by digging trenches to make a passageway for traffic.

COST AND MAINTENANCE OF THE ROAD, ETC.

The total cost of building this roadway, which has an average width of 6 metres, and is 70$\frac{5}{8}$ miles long, was 1,885,969.54 francs ($377,193.91), or 16,690 francs ($3,338) per kilometre; the land acquisitions amounted to 110,652 francs ($22,130.40), or 989 francs ($197.80) per kilometre. The company also expended 698,713 francs ($139,742.60), or 6,238.50 francs ($1,247.70) per kilometre for buildings, etc., so that the entire cost foots up 3,000,000 francs ($600,000).

The company has a yearly average outlay of about 100,000 francs ($20,000), or 893 francs ($178.60) per kilometre, for repairs, etc., to the roadbed, etc., and its annual net revenue is between 450,000 and 500,000 francs ($90,000 to $100,000).

TRAFFIC OVER THE ROAD, ETC.

The average amount of freight that passed over this road during 1885, 1886, and 1887 was 20,700 tons annually. It has, however, increased since then, and in fact is constantly augmenting. The general character of the merchandise transported includes the following imports: Iron, all kinds of metals, leather, salt, rice, sugar, petroleum, manufactures, fruits, hardware, etc. The articles exported passing over the road are, principally, flour, wheat, seeds, wool, licorice, textile fabrics, bones, butter, oil, etc.

These goods are transported in covered wagons or carts, each being $3\frac{1}{2}$ metres long, $1\frac{1}{10}$ metres wide, and $\frac{8}{10}$ metre high, and weigh, when empty, 700 kilograms; loaded, 1,500 kilograms. This wagon load of only 800 kilograms may appear light, but it must be borne in mind that the road traverses Mount Lebanon at an elevation of 4,630 feet, with some very steep grades. The number of these freight carriages that pass daily between Beirut and Damascus is 28, 14 each way, each of them being drawn by 3 large mules.

Besides the freight traffic there is a "diligence," or omnibus, leaving both Beirut and Damascus every morning, weighing 1,500 kilograms. These "diligences" are capable of accommodating 16 persons in winter and 18 in summer, allowing each passenger 12.820 kilograms of baggage; they are drawn by 3 horses and as many mules.

There are also two "mail" omnibuses passing daily over the road, one from Beirut, the other from Damascus; their weight is 750 kilograms each, and they carry 5 passengers, entitled to 6.410 kilograms of personal baggage; 3 horses or 2 horses and 1 mule are sufficient to draw them.

EFFECT OF THE ROAD UPON LAND VALUES, ETC.

The effect of this highway upon land values has not been very marked, owing to the arid nature of the land traversed and to the absence of villages and scarcity of water along its line, though both the outskirts of Beirut and Damascus are largely benefited.

But the result proved entirely different to commerce. The facilities of communication and the reduction in the cost of transportation have developed the traffic to five times its former proportions, and Beirut, with a population of only 25,000 souls in 1860, now claims 120,000 inhabitants. Damascus has remained nearly stationery in so far as its population is concerned, but its traffic has greatly augmented.

STREETS IN SYRIAN CITIES.

The streets of the different cities of Syria are fully adapted to surrounding conditions and circumstances, but they do not contain any elements or features that would prove of value or even interest in this report.

ERHARD BISSINGER,
Consul.

UNITED STATES CONSULATE,
Beirut, February 10, 1891.

CONTINENT OF AFRICA.

EGYPT.

REPORT BY ACTING CONSUL-GENERAL GRANT, OF CAIRO.

STREETS OF CAIRO.

The new or improved city streets and avenues of Cairo are generally roads bordered by sidewalks. In the country the sideways are simply formed by earth thrown on each side of the road. The city roads are constructed on the Macadam system. An experiment was made to build a road with asphalt, melted and poured hot on a bed of broken stones. The result was bad.

Another experiment was made with slabs made of a concrete composed of broken stones mixed with liquid natural asphalt. The result was better than with the preceding method.

Finally, a wooden pavement, made of pine wood resting on a solid area of concrete, has proved satisfactory for more than one year since it was placed on one of the most frequented roads of Cairo, but it is expensive.

The macadamized roads are generally built of small stones, forming a bed 0.25 metre thick. The agglomeration of the materials is produced by means of a steam compressing roller on the Gellerat (Paris) system, and weighing 18 tons. In few instances compressors drawn by animals are used; but the work is not so well done.

The cost of building macadamized roads is from about 59 to 74 cents per square metre.

When small repairs are needed they are simply made by laborers, but extensive repairs are made by laying over the surface of the road the quantity of new materials necessary to restore it to its former thickness.

The expenses incurred on account of the ordinary and extraordinary repairs of the macadamized roads of Cairo, including work and materials, amounted during the year 1889 to $82,548 for a surface of 952,500 squares metres, or 8$\frac{3}{4}$ cents per square metre.

These expenses do not include the watering of the roads, which is done twice a day during the summer and once a day during the winter.

The length of the macadamized roads of Cairo, not including public squares, is 58 miles, while the other ordinary roads have a length of 132 miles.

EFFECTS OF IMPROVED PUBLIC ROADS.

The value of lands through which the new roads have been laid has considerably increased, and in the northern side of the city, at Zaher, it is at least ten times greater.

Twenty years ago ground in the Ismailieh district was granted free under condition that dwellings would be erected on it; but as at that time there were no roads made in that part of the city, many of the grantees did not care to spend money for building, and they let their concessions lapse; but as soon as roads were built there was a greater demand for the land, and nowadays it is sold at $10 a square metre.

Eight or nine years ago some bankers bought land from the Government in the Tewfikieh district at $1.88 per square metre, and now the average price is about $7.40.

The above figures demonstrate the effect of created or improved public roads upon land values.

Twenty-five years ago there were no hackney coaches at Cairo, on account of the difficulty of circulation in the interior or exterior roads of the city. Distances were traversed on horses, mules, donkeys, or camels.

The work of improvement of roads began in 1868, and in a space of ten years the actual system of streets and roads was completed. Such improvements have greatly facilitated commercial transactions and considerably increased the value of estates bordering the great avenues which have been opened in the old part of the city.

Public health has greatly improved in consequence of the creation of new quarters in the western and northern parts of the city.

These parts were formerly covered with huge heaps of rubbish, the dust from which, raised by the least breath of wind, was blown all over the city, causing diseases of the eyes, lungs, etc. The wide avenues opened in the midst of narrow and tortuous streets have produced an effective drainage conducive to the salubrity of these streets and lanes.

Thanks to the creation of new districts and to the opening of large avenues in the old city, Cairo has become a city pleasant for everybody in general to live in, and especially for foreigners.

HIGHWAYS.

In the several towns of Egypt, except Cairo and Alexandria, there are very few metaled roads. The others are merely of beaten earth, kept wet and smooth, and, considering the climate and the smallness of the traffic, they answer sufficiently well.

Until two years ago it may be said there were no country roads at all, and it would have been impossible to convey agricultural produce on a wheeled cart from one center of population to another.

A beginning has been made, however, first in Dakahlieh and Sharkieh and then throughout the other provinces, of constructing simple

unmetaled roads, 5 metres wide, with bridges over the canals, leading generally to railway stations or sometimes to points on the river. Their construction is being defrayed by a local tax not exceeding 20 or 25 cents per acre for 1 year only. They are maintained afterwards at government expense. It is too soon to pronounce yet on the value of these roads, but they are very popular among the people.

The information contained in this report was kindly given me by the department of public works.

LOUIS B. GRANT,
Acting Consul-General.

UNITED STATES CONSULATE-GENERAL,
Cairo, April 9, 1891.

MOROCCO.

REPORT BY CONSUL-GENERAL MATHEWS, OF TANGIER.

Morocco furnishes no material whatever for framing such a report as desired through your Department.

There are no roads in this country, no railroads nor vehicles of any sort.

The narrow and crooked streets of the cities and towns of Morocco are partly paved with rough cob stones, which makes walking a difficult task. The roads are only trails made by the passing and repassing of animals. In fact the Government discourage instead of encouraging the building of roads, and ever oppose the paving of the streets of certain towns.

F. A. MATHEWS,
Consul General.

UNITED STATES CONSULATE-GENERAL,
Tangier, January 22, 1891.

ST. HELENA.

REPORT BY CONSUL COFFIN.

The streets, of which there are but two on the island, one leading from the seaside, a mile or more up the valley, to the head of the town, the other, a short street of a few hundred yards, branching off the main street and leading to the Longwood road.

They were built many years ago with slave labor by different governments and the old East India Company from material taken from the side hills, consisting of stone or lava and clay or mud.

The hills are composed of alternate layers of the above material in layers of from 2 to 10 feet or more in depth, of a volcanic formation.

The stone is broken and put on the streets and covered with mud or clay; they are repaired with the same material and in the same manner. As it is not rolled down, in dry weather it is very dusty and in wet weather very muddy.

The roads, of the same material as the streets, are built along the side hills by leveling and building a stone wall on the off side of the road to prevent the carriages and travelers from going over, as the hills are very steep, and they would, in many places, be thrown some hundreds of feet to the bottom of the hill. These roads make sharp turns in the shape of a V in their zigzag routes to the top of the hills, and to go a short distance you travel many miles; by any road from Jamestown it is laborious for man or beast, as it is a continual ascent for 2,000 feet; then there is some level road interspersed with steep hills. Carriages and teams all use shoes for one of the hind wheels, and with a single carriage a man leads the horse, as it is not safe to drive by reins, the hills are so steep; double carriages are driven by a postillion who rides one of the horses, with a boy following to put on the shoe when necessary.

The roads and streets are kept in order by the soldiers belonging to the engineer corps; as their number has been reduced, very little is done on the roads or streets now. There are a great many miles of roads around the island, which must have cost, even with slave labor, an enormous amount of money to build, as many miles of blasting and wall-building had to be done. The actual cost of these roads can not be ascertained, as they have been built by the different governments which have had possession of the island.

There is no doubt that these roads when built increased the value of property along their route, but in the present state of the island, which is fast decaying, they have no effect, as the country seats along their route are many of them vacant and in ruins, and the farming land turned into pasture, and of little value.

The primitive manner of construction and the material used are such that I should not think they would be of any interest or benefit to the inhabitants of any part of the United States.

JAMES B. COFFIN,
Consul.

UNITED STATES CONSULATE,
St. Helena, January 24, 1891.

SIERRA LEONE.

REPORT BY CONSUL BOWSER.

The streets in this colony and city are all alike. There is an underlying bed of soft calcareous rock, with various depths of earth, from 3 to 5 feet. The roads are made by digging trenches on each side, and throwing the dirt to the center and leveling, then a top dressing of

broken stone completes the street or road. As there are but 2 horses and 1 dogcart in the colony, the roads are easily kept in repair when only naked feet tread them.

The roads that lead far into the country are nothing more than narrow paths, as all travelers go single file. The cost of maintaining the roads here are the filling up of some ruts that may be caused by washouts during the rainy season. You will readily see that roads and street making are of little expense in this country.

BOLDING BOWSER,
Consul.

UNITED STATES CONSULATE
Sierra Leone, December 29, 1890.

AUSTRALASIA.

NEW SOUTH WALES.

REPORT BY CONSUL GRIFFIN, OF SYDNEY.

CITY STREETS.

The streets and roads of New South Wales are partly made and managed by the government and partly by the municipalities. The number of miles of streets and roads owned by the municipalities at the end of 1889, the latest statistics available, was 5,790. Of these 2,799 were regularly formed and metaled and 2,991 were not formed. The cost of their construction, or their estimated value, is given by the government statistician at $17,959,455. The length of the streets and roads in Sydney and the suburbs was 1,568 miles, 115 miles of which are included within the boundaries of the city. The boundaries, however, do not include anything like the total area of the city. The estimated population of the city and suburbs within a radius of 10 miles is close on to 420,000, whilst the population of the municipality is only about 230,000. Nearly all the streets and roads of the city are formed, curbed, and bordered by pavement of asphalt, tarred stone, artificial stone, etc. About 300,000 square yards of the city are paved with wooden blocks, or about a twenty-second part of the entire area. These blocks are laid wherever the traffic is heavy enough to require a superior pavement. The macadamized or metaled pavement, being less expensive, seems to answer very well for the purpose of light traffic.

CONSTRUCTION AND MAINTENANCE.

Both the government and municipal authorities advertise for tenders for the construction of streets and roads over which they have control, and the contracts are given to the lowest and best bidders. Great care is exercised in awarding these contracts. The specifications are very full and the execution of the contracts must meet with the approval of the authorities.

In Sydney, if at any time the work is not carried out in strict conformity with the contract, the city surveyor will interfere and inform the contractors that if not remedied the municipality will take the work out of their hands.

Parties tendering for contracts must deposit the sum of £20 ($97.35) on or before the time specified for the reception of the tenders. The deposit will be returned in all cases of nonacceptance, and to the per-

son whose tender has been accepted when he shall have completed his work according to the requirements of the bond he is called upon to give.

TARRED METALED PAVEMENT.

The material employed in the pavement of streets for light traffic consists principally of bluestone or metal, of which there is an inexhaustible supply in the colony. The foundation of the pavement must be approved of by the city surveyor. Where rock exists too near the surface to receive the ballast it is to be broken up and loosened to a depth of at least 8 inches below the level of the underside of the ballasting. The foundation is properly consolidated to a uniform depth of 9 inches, and a coating of new hammer-dressed rough pitchers of the hardest description of sandstone laid lengthwise across the road in close and regular rows, breaking joint. As rough pitchings are well rammed, the breadth of the upper edge must not be more than 7 inches, with a length of from 12 to 15 inches. All the interstices are filled in with stone chippings firmly wedged, well keyed in, and blended with sand well shaken into joints by ramming. The stone for the ballasting is broken to a 2-inch gauge, 2 inches thick, and covered with a coating of tar. It is then rolled to a finished grade and an additional layer of the same material, prepared in the same way, is spread to a depth of 3 inches and again rolled. The whole is cemented together in one unbroken mass by a covering of tarred screening. The latter is made even in thickness and solid after which a thickness of 1 inch tarred screening of the finest bluestone and dust from the crushings is put in as a finishing coat.

WOOD PAVEMENTS.

The authorities of Sydney before entering upon the extensive construction of the magnificent roadbeds of the city made the most careful inquiries as to the various kinds of pavements in use in the principal cities of the world, and a series of costly experiments were made with the kinds generally regarded as the best in use. These included granite-set pavements, monolithic, sheet asphalt, wood pavements, etc. It was their desire to get a pavement with a due regard to economy or cheapness and afford a good foothold, be impervious, durable, noiseless, adapted to various grades, yield no detritus, and offer the least resistance to traction. No particular kind of pavement complied with all these conditions, but the one finally adopted for heavy traffic seemed to come nearer to them than any other. A committee was appointed, composed of some of the ablest physicians and scientists in the colony, to report on the sanitary conditions of the wood pavements that had been in use in Sydney and other places, and although the committee made a sweeping condemnation of all kinds of wood pavements it was shown that the districts in which wood pavements had

been in use for a term of years in Sydney were healthier than those without them.

The committee in concluding their report said:

We beg to express the opinion that wood is a material that can not be safely used for paving unless it can be rendered absolutely impermeable to moisture and so laid that while the entrance of the water between the blocks is rendered impossible the separation of the fibers at the surface by the concussion of the traffic is also effectually prevented. These conditions have nowhere, to the knowledge of the board, been fulfilled. In this city no attempt to fulfill them has been made and the analyses show that the blocks in actual use here have absorbed an amount of organic filth which is large in comparison with the short time during which they have been laid, and which is distributed throughout the blocks in such a manner as to show that their complete impregnation is only a matter of time. The foul and dangerous processes to which this impregnation of the wood gives rise when with it is combined alternate wetting and more or less thorough drying by the sun and the construction which, while it does nothing to exclude the air entirely, of necessity interferes with its free circulation, are well shown by experiment, and it is perhaps well to point out that the use of sea water to lay the dust is so far from tending to prevent these processes that in addition to introducing the organisms proper to sea-water where otherwise they would not be found it appears to have given rise to certain forms of life which hitherto have not been recognized, and which flourish in conjunction with the better known forms of both fresh and salt water. In offering this opinion your board has certain advantages which wood pavement offers in comparison with other kinds in mind, and does not lose sight of the fact already here recognized, that every pavement is a compromise. But before a given material or mode of construction can be scientifically admitted as an alternative to other kinds and to other modes, it must be shown that its admitted defects are remediable or that they are of no greater consequence than the defects of every other available material. Neither has been shown in the case of wood, so far as the careful researches of your board go the porous absorbent and destructible nature of wood must in their opinion be declared to be irremediable by any process at present known, nor, were any such process discovered, would it be effectual unless it were supplemented by another which should prevent fraying of the fiber. Still less can the defects of wood be considered to be of less consequence than the defects of other kinds of material. The covering of roadways to a vast extent of surface with decaying vegetable material has been shown in the United States to be a cause of malarial fever, and an aggravation to yellow fever, in a degree of probability which is very high; and these results are such as knowledge of the usual effects of decaying vegetable matter under other but similar circumstances would lead your board to anticipate. Wood, then, should not be accepted as an alternative to other materials; and if in other climates than that of the American cities referred to, and under other modes of construction than are used in Sydney, the same effects are not known as yet to have followed, it must not be forgotten either that wood paving has nowhere been so largely used in proportion to other kinds as in America or that the disastrous and obvious effects noticed in that country are not the only serious effects which wood may cause. In this city it may, perhaps, be considered that an amount of wood has has not yet been laid sufficient to affect the public health, whatever its condition within reasonable limits may be; and upon this ground your board does not recommend that the present paving should be removed, but that the board of health should be empowered to examine it, and to report upon it, from time to time, with a view of ascertaining its behavior under longer exposure to weather and traffic than it has yet had; and that it should be no longer watered but cleansed by sweeping at least twice a day (the sweeping to be done at right angle to the direction of the street, or parallel to the courses, so that the latter may be cleared out by the broom) in order

that destructive dampness and penetration of dissolved organic matter may be reduced as much as possible. But the presumption is, upon the evidence here adduced, that in this climate the results alluded to would ensue if the extent of surface were sufficiently enlarged or fouling and decay sufficiently extensive. Your board therefore recommends that the paving of the streets of this city with wood should be discontinued; and desires to add that this recommendation is intended to apply not to the particular mode of construction here adopted alone, but to the material itself, and to every known method of construction.

In spite of this opinion the authorities soon found that by keeping the pavements clean and in good order all the objections urged were overcome and a decided improvement was noticed in the health of the city. The blocks used for the pavements consists of various kinds of Australian hard wood of the eucalyptus species such as red gum, tallow wood, wooly butt, black butt, blue gum, etc. The wear and tear on these blocks proved slight when compared with the blocks used in the European cities. Blocks taken at random from the center of one of the principal streets in Sydney subjected to very heavy traffic had worn only one-sixteenth of an inch in several years. Samples of the Australian hard woods used for paving the streets were sent to New York by Mr. R. W. Richards, city surveyor. Mr. Richards has for many years been a strong advocate for the use of these woods and his experience and judgment have had great weight with the municipal authorities. The blocks used are cut into cubes of 6 inches long, 3 inches thick, and varying in width from 6 to 9 inches, which limits must not be departed from, except in cases of chasms when smaller blocks may be necessary. The blocks are to be laid on a foundation of concrete 6 inches in depth and composed of the following material, viz, the best brands of cement mixed with either the following ingredients:

First. Gravel and coarse, clean, sharp river sand in suitable and approved proportions the gravel not to be larger than 2½ inches gauge, the concrete to consist of 1 cask of cement to 24 cubic feet of gravel and sand.

Second. The aggregate to be a compound of clean blue stone, mixed with dust and screening obtained from crushing, in the following proportions: 1 cask of cement to 20 cubic feet of blue stone broken from 1 inch to 2½ inches gauge, and 15 cubic feet of fine blue stone screening of not more than five-sixteenths of an inch gauge.

The concrete must be well worked and to a smooth surface, and receive a thin coating of two parts of clean river sand to one part of cement. When the concrete is thoroughly dry the blocks are laid on it as follows: Three rows longitudinally along curbs throughout the whole extent of the curbing; the remainder of the blocks to be laid transversely across the street to form any angle between 30 degrees and 45 degrees, or as the city surveyor may direct. The end of the blocks butting against rows parallel to curbs to be cut so as to form a close and even point. The joints to be separated by not more than one-fourth of an inch, and to be regular and uniform. The city surveyor noticed that

when the joints were too far apart the noise of the traffic was increased, and he directed that they be made narrower. At first they were 1 inch in width and were reduced to three-eighths of an inch, and then to one-fourth of an inch, as heretofore mentioned. In paving George street, the principal thoroughfare of the city, four methods were adopted:

. First. Joints of three-eighths of an inch coated with screenings and tar.

Second. The blocks were laid with butt joints dipped in tar and hammered up close and afterwards thoroughly grouted by sweeping boiling tar and river sand.

Third. The blocks were laid on a roofing of tarred felt, jointed with strips of the same material properly hammered up, to render close and even joints.

Fourth. Three eigths joints grouted with pitch, river sand, and tar. The street was opened for traffic in July, 1888, and it was noticed that the noise had been minimized and the slipperyness of the pavement overcome by sprinkling sand upon it. Mr. Richards, the city surveyor, is of opinion that the method of laying the blocks without grouting is by far the best. At first the blocks were painted on all surfaces with hot tar, and stacked for at least 4 hours and then laid in the work, at every twelfth row hammered up close, a plank 12 feet long, 6 inches deep, and 2 inches thick being used as a beating surface. Upon completion of a length of 1 chain the surface was well swept with hot tar, sprinkled with hot sand, and again with tar, sufficient quantity being used to form a plastic paste with which the joint was afterward thoroughly flushed up. After 3 months' traffic upon this section the necessity of an after treatment was apparent, as the joints were gaping, and in some instances the blocks were loosened. The means taken as a remedy were that the blocks were well watered and when fairly dry again the joints swept in flush with sand and tar, as before described; since which, the pavement has maintained a most satisfactory condition, notwithstanding that it has been subjected to the most variable influences. The Castlereagh street pavement, from Hunter to Liverpool street, a distance of 58 chains, afforded opportunity for further experiment, and for a length of 8 chains the blocks were laid at an angle of 45 degrees to the curb, by which a wheel in its revolutions is on at least 2 rows of blocks, and the result showed that the noise occasioned by the jarring over the joints was reduced to a minimum. In the same work a butt-jointed pavement was laid for a length of 7 chains, with a gradient of 1 in 65, and a convexity of 1 in 60. Mr. Richards states when the gradient does not exceed 1 in 40 the butt jointed can be laid with advantage.

The convexity can in such cases be reduced to 1 in 80. In anticipation of expansion of the blocks, a seam of sand 1½ inches wide was laid on both sides of the roadway, between the curb and the blocks. This section has been traveled upon for nearly 12 months and has not yet

required attention. The woods used in these works were of the classes respectively known as black butt, spotted gum, and tallow wood. During the last 2 years portions of the areas, wood-paved, with the wide joint, have been renewed, with the narrower joint. The old blocks obtained from these areas have been utilized in the paving of lanes and narrow ways adjacent to wood-paved thoroughfares. The work was done by days' labor, the foundation being prepared with the best material obtained from the excavation of the former roadway, the blocks bedded on a layer of sand 3 inches in thickness and the joints grouted with sand and tar.

The steepest grade is 1 in 17.2 and is a length of 4 chains. The greatest width of roadway is 275 feet (at George street south, near railway station), in portion of which there is also the greatest cross fall, viz, 1 in 17, which was necessitated to conform with the tramway construction. At first the intersections of the streets were paved with cube settings, but Mr. Richards recommended their removal and wood blocks put in place of them. This plan he pressed continually upon the authorities until it was finally adopted. A careful examination of the work done on George street and on King street afforded an opportunity for comparing the wear of bluestone cubes with that of wood blocks. The bluestone cubes, after having been subjected to traffic for 5 years and upwards, showed an average wear of 1 inch per annum, whilst the wood blocks, which had been put down for a longer period, subjected to an equally heavy traffic, wore only at the rate of 1.26 of an inch per annum. Blocks put down in 1888 under the present system have also been examined and the wear was only at the rate of 1.50 of an inch per annum.

From these results it is estimated that, after making full allowance for depreciation and contingencies, the minimum life of wood pavement is about 16 years, or from 3 to 4 times that of bluestone cube set pavement.

SIDEWALKS.

The pavement of sidewalks or footpaths in Sydney consists of flagging, artificial stone, and tar paving, etc. These pavements appear to give satisfaction.

Under the corporation act of 1879, it was provided that certain portions of the footways should be paved with flagging and others with flagging or tar pavement. The main thoroughfares were to be with flagging and the residential streets with flagging or tar pavements.

At first the average cost of flagging was 14*s.* ($3.41) per square yard and the tar pavements 2*s.* 6*d.* (60 cts.) per square yard. The property owners were charged with the cost of the work, but those on the main thoroughfares objected very seriously to be compelled to pay for flagging whilst it was left to the option of the residential owners to have

either flagging or tar pavements, and the act was finally amended so as to apply equally to both classes of owners.

The tar pavement was most generally in use. Mr Richards, however, stated that the tar pavement is only desired when it is apt not to be disturbed, and he finally succeeded in getting a medium between the two adopted called artificial stone. The following is a description of the method of constructing the latter pavement: The ground being excavated to a sound and approved foundation—an aggregate composed of one measure of cement to two of clean coarse sharp sand thoroughly mixed dry and made into a mortar, with the least possible amount of water—broken sandstone not exceeding 1½ inches in their largest dimensions, thoroughly cleaned from dust and dirt, drenched with water, but containing no loose water in the heap, to be immediately incorporated with the mortar in such quantities as will give a surplus of mortar when rammed. When the proper proportion is ascertained, it is afterwards regulated by measure. When spread it is thoroughly compacted by ramming, until free mortar appears on the surface, which must be made exactly parallel with the surface of the pavement to be laid.

Before this base is thoroughly set a wearing surface 1 inch thick is laid (to a uniform and plane surface and properly smoothed), composed of one part of Portland cement to one part of clean, coarse, sharp sand, cut into diamond or rectangular slabs, in sizes not larger in area than 1 square yard.

In this pavement (from result) it seems advisable at every length of 12 feet to allow a groove 1 inch deep by 1 inch wide, so that the wearing surface should set freely, after which the groove is filled in with asphalt or other suitable material. The scoring is done with a trowel, and cut not more than a quarter of an inch deep, and with a uniform width of one-eighth of an inch.

The traffic in George, Pitt, York, and Sussex streets is said to be as heavy per square yard as in any other city in the world. The average number of vehicles passing George street near the town hall per day for 12 hours is 11,960.

GRANITE PAVEMENTS.

The cubes of the granite pavements are very carefully laid on a concrete foundation of 6 inches in depth. In 1887 there were 600 square yards of this pavement laid at a cost of 22*s*. 7*d*. ($5.48) per square yard, and 337 yards laid on sand at a cost of 15*s*. 3¼*d*. ($3.71½) per square yard. In 1888 about 2,000 square yards were laid on sand, varying in cost from 6*s*. ($1.46) to 13*s*. 10*d*. ($3.48) per square yard. In 1889 there were 2,726 yards laid on sand at a cost of 5*s*. 1*d*. ($1.24) per square yard. In 1890 there were 9,687 yards of wood paving laid at a cost varying from 13*s*. 7*d*. ($3.30) to 19*s*. 4*d*. ($4.70) per square yard. The following table shows in detail the cost per square yard of wood paving carried

out during the years 1889 and 1890; also the cost of cube set paving for 1889 in Sydney:

WOOD PAVING.

When opened to traffic.	Name of street.	Locality.	Area in sq. yards.	Cost per sq. yard.	Remarks.
				s. *d.*	
1889. January	Pitt	At Spring and Bond streets.	720	16 7¼	Cube-set crossings removed and wood blocks substituted.
Do.	William	At Boomerang and Yurong streets.	82	19 3	Do.
May	George	At Gipps, Engine, Hay, and Goulburn streets.	2,980	18 0½	Do.
June	Elizabeth	Hunter to Liverpool street.	11,908	19 8	Hardwood blocks laid on 6-inch concrete.
1890. January	Kent	Argyle to Crescent street.	6,510	19 10	Do.
April	Pitt	At Hunter street	562	15 0	Cube-set crossings removed and wood blocks substituted.
July	Bridge	Pitt street, Macquarie place.	1,775	19 8½	Hardwood blocks laid on 6-inch concrete.
June to December.	Clarence	At Margaret street			
	George	At Argyle, Bathurst, Druitt, Hunter, King, Liverpool, and Margaret streets and Queen's place.			
	Pitt	At King, Market, and Park streets.	7,270	13 7	Cube-set crossings removed and wood blocks substituted.
	York	At Barrack, Druitt, Erskine, King, Market, and Wynyard streets.			

CUBE-SET PAVING.

When opened to traffic.	Name of street.	Locality.	Area in sq. yards.	Cost per sq. yard.	Remarks.
1889. July	Alger's road.	....	625	5 1	Old cubes laid on sand.
May	Stream	Myrtle street to Paint's lane.	249½	5 1	Do.
September	Harbor	Pier to Liverpool street.	1,852	5 1	Do.

REPAIRS.

The cost of repairing wood paving in Sydney is less than that of any other kind when the amount of traffic is taken into consideration.

The total expenditures for repairs to wood pavements is very small. In 1890 considerable expenditures were made on account of the gas company, sewage board, etc., but the general repairs amounted to only £65 ($316.32) during the year.

The city surveyor states that the annual cost for repairs to wood pavements is so small as to be hardly worth taken into consideration, and that the chief outlay is in soundings. The whole expense, for repairs, including the cost of watering the streets, is about one-sixteenth part of a penny, say one-eighth part of a cent per square yard per annum. The annual cost of repairing the macadamized streets is about 8⅛ cents per square yard. Taking separate areas on streets similarly constructed and over which continual traffic passes in the central part of the city the cost is from 8*d.* (16 cents) to 11*d.* (22 cents) per square yard.

SEWERAGE.

This report would be incomplete without some mention of the admirable system of sewerage that has been so successfully carried out by the authorities of Sydney and which has done more than anything else to improve the health of the city.

In 1875 the government appointed a board, called "the Sydney city and suburban sewage and health board," for the purpose of inquiring into and reporting upon the best means of disposing of the sewage of the city and suburbs, and also for the protection of the health of the inhabitants. The board consisted of fifteen members, including the surveyor-general, several of the professors of the Sydney University and members of the board of health, the city surveyor, the engineer in chief of the road bridges, the government analyst, etc. The board submitted twelve progress reports, all of which dealt with very important questions and contained many valuable and practical suggestions.

In order to understand the system adopted it should be mentioned that the city of Sydney is situated on the southern shore of Port Jackson, about 5 miles from the head or entrance to the harbor from the South Pacific Ocean. Professor Warren, M. I. C. E., of the University of Sydney, to whom I am indebted for much valuable material in the preparation of this report, states—

That from a point on the ocean cliffs, about three-quarters of a mile south of the South Head, and known as Ben Buckler Point, a high ridge extends in a westerly and southwesterly direction, having a mean elevation above the sea level at its eastern end of about 200 feet and declining thence to about 100 feet. The distance to the north of this ridge, on which the principal portion of the city is situated, drains to Sydney Harbor, and the southern slope drains to Botany Bay and Cook's River.

It was decided that the sewage of those portions of the city of Sydney and its suburbs which naturally drain into Port Jackson should be collected into an outfall sewer and led away by the most direct course and at as low a level as practicable and discharged finally into the sea near Ben Buckler Point, while the sewage of the southern district should be collected into a separate system and taken to Botany and there to be utilized as a sewage farm, there being an ample area of light sandy soil at a convenient level for irrigation by gravitation available for the purpose.

The area drained by the northern system is about 5,300 acres, and the area drained by the southern system about 1,100 acres. The whole of the northern and southern outfall sewers have been completed and much work done in extending the minor sewers in connection with the system. Professor Warren states that the northern outfall sewer commences near the intersection of the Newtown road and Parramatta and discharges into the ocean near Ben Buckler Point, is 5½ miles in length, uniform in section, and varying in size from 4 feet 6 inches by 3 feet 6 inches at its upper end to 8 feet 6 inches by 7 feet 6 inches for a length of 1 mile at the outfall end, with a fall of 3 feet 6 inches a mile. At a

quarter of a mile from the head it is joined by "the Prince Alfred Hospital connecting sewer" and by the "Pyrmont branch sewer;" at the corner of Oxford and Liverpool streets, $1\frac{1}{4}$ miles from the head, it is joined by the King street and several other intercepting branches. Besides collecting sewerage at these branches it intercepts a number of old sewers at Rushcutters Bay. A storm-water overflow is provided along the entire length, and from this point an overflow sewer was built to carry the storm water into the bay. It is one-half a mile in length, 4 feet 6 inches by 3 feet 6 inches in size, with a fall of 1 in 200, and discharging above high-water level. A swamp of 1,000 feet in length had to be crossed by this overflow sewer. This part of the work is carried on arches of 25 feet span and 3 feet 6 inches rise. To form the piers for the arches concrete cylinders of 10 feet external diameter were sunk through the spongy ground until a stratum of clean sand was reached. The cylinders were filled with concrete and the arches turned. The thickness between the soffitt of the arch at the corner and the invert of the sewer is 12 inches. The depth of the cylinders varies from 10 feet to 33 feet. The whole of the work in the cylinders, arches, and sewer is of concrete.

Provision is made at the other points for storm-water relief and diversion of sewerage when necessary. The northern system comprises the following new brick and concrete sewers:

Outfall sewer, 5 miles 2,700 feet; Prince Alfred Hospital intercepting sewer, 1 mile 1,400 feet; Pyrmont branch, 1 mile 2,100 feet; Kent street intercepting sewer, 1 mile 3,900 feet; Bridge street and Harrington street intercepting sewer, 1 mile 4,700 feet; Riley street and Bourke street intercepting sewer, 2,000 feet; Lacrozea Creek branch, 1,500 feet; Rushcutter's Bay overflow sewer, 2,500 feet; proposed extensions to Glebe, Balmain, etc. (shown in dotted lines on sketch plan), 5 miles 2,000 feet; total, 18 miles 680 feet. Some stoneware pipe sewers have also been laid up to 24 inches diameter, and a large amount of work remains to be done in laying pipe sewers or submains. Concrete has been largely used in the construction of the sewers, and all bricks used in the work are of very high quality. The concrete (except that used for packing purposes) is composed of blue stone, broken to a $1\frac{1}{2}$-inch gauge, sand and Portland cement in the following proportions: Four parts of stone, two parts of sand, and one part of cement. The bricks were nearly all supplied from two brickyards, and average samples taken from them were tested at the Sydney University Engineering Laboratory with the following results: Average crushing resistance per square inch, 2,782 pounds and 2,228 pounds. The crushing resistance of English Stourbridge fire bricks is about 1,717 pounds per square inch, and of London red brick about 808 pounds per square inch. The tunnels are lined throughout, the minimum thickness of lining adopted being $4\frac{1}{2}$ inches. In rock tunnels the lower part of the sewer up to a height of 12 inches above the springing level is lined with bluestone concrete, and the arch is closed with brickwork packed solid to the rock with sandstone concrete. In very wet rock a ring of brickwork ($4\frac{1}{2}$ inches) is laid inside an outer lining of concrete and subducts, which were afterwards closed, were used during construction in order to secure water-tight work. The outfall sewer from Oxford street to the ocean, a length of $4\frac{1}{2}$ miles, is rendered to three-fourths of its height, and the brick arch above that level is pointed. The remainder of the outfall sewer and the branch sewers are rendered all round with cement mortar, composed of one part Portland cement and two parts of sand. Every lot of cement brought on the work is tested at the head office, where complete testing ap-

paratus is provided, and all cement which does not fulfill the specified conditions, or appears to be of inferior or doubtful quality, is rejected. The sewers are constructed chiefly in tunnels, and a great portion of the tunneling is in sandstone rock. Numerous shafts were sunk for the driving of the tunnels, and to be used for ventilation afterwards, the deepest one being 240 feet. The rock tunnel excavation was done by blasting and presented no difficulties. In some cases the drilling was done by percussive rock drills worked by compressed air, and where compressed air was used for this purpose it was also used to work the winding engines. In other cases the drilling was done by hand and ventilation was provided by Root's blowers.

Professor Warren states that the portions of the work which present most interest from an engineering point of view are on the outlet end of the outfall sewer. For 1 mile, commencing at the outlet, the sewer is 8 feet 6 inches by 7 feet 6 inches, and for the remainder it is 8 feet 2 inches by 7 feet 2 inches. It is constructed in tunnel on sandstone rock on this length for 3,960 feet, and in water-charged sand 1,643 feet, and in open cutting in water-charged sand for 2,967. This part of the sewer Professor Warren states is very interesting on account of the novelty of the design, there being nothing like it as far as he is aware hitherto constructed. He says:

For draining the water charged sand nine centrifugal pumps were used with 6-inch to 9-inch pipes. Pumping wells were sunk to one side of the sewer trench and close timbered to the foundation level; the sumps below this level, a few feet in depth, being steened with concrete to prevent any water entering except through a pipe built in the concrete and connected with the subduct laid along the center of the sewer trench and tunnels. The subduct consisted of 9-inch earthenware pipes laid in hard wood boxes open at the top and packed with broken stone. These boxes were made water-tight, and the sides were carried up about 2 inches above the foundation level so as to prevent any water entering from below that level, except at the end of the duct, which was always kept some distance ahead of the concrete work. During the construction of the sewer, openings through the concrete were left over the subduct at intervals of 200 feet, and lines with rakes attached were passed through from one to the other, and these lines were occasionally pulled backwards and forwards to keep the pipes clear of silt or other obstruction. Two traveling cranes with 30-feet jibs were used for raising the sand from the trenches, which were sunk with a batter of one in eight and close timbered at the sides.

The main southern section of the sewer drains the southern slope of the city, including several of the most important boroughs, the area being over 1,100 acres. The cuttings in some places are 30 feet deep. Professor Warren says that where the sewer passes over natural water courses concrete culverts have been constructed through which the streams are carried under the sewer, so that the land drainage and the interest of market gardeners are not interfered with. The main sewer is constructed of bluestone lined with brickwork and sandstone concrete. For the lower portions, it is rendered on the inside with Portland cement mortar half an inch thick in the proportion of one part of cement to two of sharp, clean sand.

The sewer is provided throughout its length with ventilation manholes and with gas check valves to prevent the sewer gas rising to the higher levels; also with flushing and penstock chambers. Three

million bricks and 35,000 casks of cement were used. In connection with the system a sewage farm of about 300 acres of loose ground has been secured for the purpose of filtering the sewerage. Suitable filter beds have been made for the disposal of surplus water during heavy rains. These beds are capable of filtering 400,000 gallons of sewage per acre in 24 hours. They are used in rotation that the very best filtering powers may be obtained. There are cultivated areas on the sloping ground toward Cook's River formed in terraces on the ridge and furrow system connected with the main carrier by means of small wooden distributors, with sluices, timber boxes, etc. The sanitary results are shown by the purity of the effluent water. The terraces and banks of the main carrier are planted with *Mecembryanthemum tigrinum*. The prepared beds are planted with sorghum, barley, lucerne, etc. This farm, together with many other valuable improvements, not usually connected with sewage, has done much towards making this great work almost unique as well as one of the most complete and satisfactory systems of drainage in the world.

HIGHWAYS.

The public roads in New South Wales, and, indeed, in all the Australian colonies from the first settlement of the country, have been built in the most substantial manner. At first they were constructed entirely by prison labor. The New South Wales road department was organized in 1857, and Mr. T. A. Coglan, the Government statistician, states that although good service was done by the road pioneers before that date, the modern system of road making may be said to have begun with the creation of the roads department. It was not known until 1867 that the whole of the roads received attention at the hands of the state. The department of roads has also the control of the bridges, ferries, punts, etc. Among the duties devolving upon the department are the selection of the work and the disbursement of the funds noted annually for the purpose. Prof. W. H. Wassen, M. I. C. E., professor of mechanical and civil engineering in the University of Sydney, has summarized the duties of the roads department as follows:

(1) The removal of all complete interruptions to traffic, more particularly to mail transit, by bridging the rivers and creeks.

(2) The improvement of all the most difficult mountain passes and swamps.

(3) The final determination of the direction of the roads and the clearing of the same, followed by drainage and culverting where most required.

(4) The forming and metaling of roads, excepting where municipalities exist.

It being almost impossible to insist on any one uniform mode of constructing the roads it was decided to adapt them as far as possible to the conditions of the country through which they were to pass, with a due regard to the requirements of the traffic and the quantity and quality of the material available.

The following are the main roads in New South Wales:

Northern road—length, 405 miles, from Morpeth to Maryland, New England.

Western road—length, 338 miles, from Sydney to Warren, through Bathurst, Orange, and many other important townships; thence prolonged to the Darling, at Bourke, by a line 175 miles in length.

Southern road—length, 385 miles, from Sydney to Albury. This road was, before the construction of the railway, the great highway between Sydney and Melbourne.

South coast road—length, 250 miles. This road, after leaving Campbelltown, ascends the coast range, along the top of which it runs as far as Coal Cliff. It then traverses the Illawarra district, parallel to the coast, and passes through the rich lands watered by the Shoalhaven, Clyde, and Moruya, as far as Eden, at the southern limit of the colony.

The public roads have nothing like the importance they formerly possessed previous to their having been superseded for the most part by the railways. The tendency now is to make the roads act as feeders to the railways by conveying the traffic from outlying districts towards the convenient stations along the railway line. The length of the roads are estimated at about 30,000 miles; of these 6,500 miles have been formed, metaled and graveled, and 4,500 miles not metaled, but drained, and upon which culverts have been built, and 7,600 miles of road through the forests of the interior marked out by cart wheels, and 1,400 miles through mountain passes, some of which presented difficulties almost immountable, and in their construction great engineering skill was displayed. Of these roads much attention has been directed to that at Bulli Pass. This great work was begun in 1867 for the purpose of opening up communication with the northern part of the Illawarra district and the Great Southern Railway at Campbelltown. The Illawarra district is regarded as the garden spot of the colony, and is remarkable not only for its fertility but for the beauty and variety of its scenery. In some places the grades are as steep as 1 in 8, but the road is perfectly straight and smooth. Another magnificent road is that around Mount George, in the Blue Mountains district, and connecting with the main road leading to the Jenolan Caves. The scenery along the road is varied and picturesque in the extreme. Although approaching very near the edges of precipices several thousend feet in depth, strong stone facings of sufficient height protect the traveler from danger and keep the roads from falling away during heavy rains.

CONSTRUCTION AND MAINTENANCE.

The colony is divided into fifty-four road districts and four hundred road trusts. The districts are managed by superintendents or engineers. The trusts have the supervision of certain grants for the maintenanee of roads of minor importance. There are also a number of important road trusts in the vicinity of Sidney all of which are well managed.

Annually votes are obtained from Parliament. First, for the main roads referred to, and secondly, for such of the minor roads as may be considered of sufficient importance to be specifically dealt with, in

which case each road is described by name and placed upon a schedule having a certain sum of money allotted to it according to importance. In addition to these votes, a considerable sum is annually voted under the head of unclassified roads. This amount is distributed by the minister for public works for expenditure, upon representations made, and after report of the officers referred to.

Special votes are made for the erection of bridges by Parliament, and also for repairs to same.

Funds having been thus allotted, road superintendents submit proposals for expenditure to the supervising engineer, who directs the calling for tenders for the various works approved of by them.

Specifications and plans are exhibited at the court-houses nearest the site of the work and advertisements inserted in the local newspapers inviting persons to send in tenders by a stated date.

Tenders having been received by the local officer are submitted by him with his recommendation to the assistant engineers, who have power to accept tenders for any amount not exceeding £200. Tenders above that amount are submitted to the minister for works for acceptance. The lowest tender is accepted in every case unless some special reason exists for passing it over. A tender having been accepted, the papers are returned to the road superintendent that he may obtain the signature of the contractor to his contract.

There are two forms of contract agreement used—a memorandum of task agreement for all sums under £200, and a penal bond for all sums over that amount with sureties in 10 per cent. on the amount of the contract.

The road superintendent prepares these agreements on printed forms, and when signed the bond is sent with all papers to the head office of the branch through the supervising engineers to be filed.

In case of task agreements the butt remains in his possession in the task book, the duplicate coupon is sent on to the head office with previous papers to be filed, and the triplicate, signed by the superintendent, handed to the contractor. (Sample copy attached.)

All contractors are bound by printed general conditions, which form part of their contract papers, and are in all cases attached to the specifications and signed by the contractor.

The contract having been signed, the road superintendent directs the contractor to commence the work.

As the work proceeds progress payments are made from time to time to the amount of 80 per cent. upon the value of the work done, upon the certificate of the superintendent, countersigned by the supervising engineer, and the balance upon the completion of the contracts.

Each road superintendent has also a public bank account, into which are placed moneys for payment to contractors and others as advised from the engineer-in-chief's office. The road superintendents are also held responsible for seeing that the votes of Parliament are not ex-

ceeded, and have to furnish, quarterly, a return, showing the financial position of the district, the balances to credit of votes, and the liabilities incurred against each.

The same routine is carried out with regard to bridge contracts. On all important bridges, the plans having been prepared by the engineer for bridges, an officer is stationed during the progress of the work, whose duty it is to see that that work is faithfully carried out, and certify to pay vouchers. This officer is responsible to and corresponds with the supervising engineer.

In cases of smaller bridges of simple design the road superintendent alone exercises supervision.

To the road superintendents, as stated before, is deputed the duty of submitting proposals for works to be carried out each year, and they prepare the necessary levels, sections, and working plans, for the ordinary formation and grading, or it is done by qualified surveyors under their direction, subject to the supervising engineer, to whom is submitted all proposals with specifications for approval before further action is taken. Wherever possible, levels are taken and sections prepared for grading the roads where construction is to be carried out. Lately a number of surveyors have been appointed for this purpose, as it has been found to be too great a tax upon the road superintendents' time, and took them away from their duties of supervision.

These surveyors travel about from district to district for the purpose of carrying on necessary surveys as may be required.

The very small wooden culverts are now, in the districts within reasonable reach of the railways, to a great extent abandoned in favor of earthenware drain pipes, which are now largely used. The sizes of these pipes are usually 12 inches, 18 inches, and 24 inches in diameter.

These are in 2-foot lengths, readily transported, quickly fixed, last an indefinite time, and form an effective and inexpensive culvert. The roads are usually formed 27 to 30 feet in width where the cross section of the ground is moderately flat and favorable, and where it is steep or rocky, making formation expensive, such as in mountain country, the width is reduced to 24 feet, 20 feet, and, in exceptionally bad country and where only small traffic may be expected, even 18 feet wide.

Metaling is usually 18 feet in width, the quantity of metal being from 1 cubic yard to the linear yard of road on all ordinary roads to 1½ cubic yards on roads where exceptionally heavy traffic exists or the soil is bad and soft.

The size of metal used in construction is usually 3 inches gauge, and it is usually laid on the earth formation without bottom ballast or pitching.

The metal is then blinded with gravel if procurable, or if not, with the best gritty material procurable within reasonable distance.

In some instances in the black-soil country where the ground is flat and water readily absorbed, so that a bad base for the roads exists, a

foundation of brushwood is laid and covered with a layer of better soil, such as shale, to a depth of 6 inches to receive the metal. This practice is not, however, common. In districts where good gravel exists this is largely used in lieu of stone on the ground of economy. A good, smooth road results, carrying light traffic well.

Before the extension of the railways into the more remote parts of the colony the three great trunk lines of road and their principal branches carried the traffic into the interior.

These trunk lines were the Great Northern, the Great Western, and the Great Southern roads and extending about 300 miles inland.

They have been each metaled from 200 to 300 miles.

The method employed to maintain was to place men, styled maintenance men, along the roads, giving each a fixed length varying from 4 to 10 miles. Their duty was to keep the surface good by spreading metal, raking in ruts as the surface became broken by traffic, attending to repairs to culverts, etc.

The supply of metal for maintaining the road was provided by annual contract, let at the beginning of each year, each contract extending over a stated length of road, the metal being supplied in heaps in such places as might be directed and there measured, the spreading being sometimes part of the contract, at others it was spread by the maintenance men.

The same system is, with modification, still in use; but it has been found that the trunk lines of road, being superseded by railways and there not being so much traffic on the branch roads severally, the work of maintaining the surface on these branches is not so costly per mile as upon the old trunk lines; therefore the maintenance men are frequently itinerant; still the same general principle is adhered to.

The maintenance men are paid at a uniform rate of 7*s*. 3*d*. per day, which is to cover repairs to tools, supplied in the first instance by the department. A code of rules and instructions for the maintenance men is supplied to each; to them they are required to adhere. (Copy attached). These men are directly subordinate to the road superintendent and engaged or discharged by him.

During the last 16 years the government have constructed 55 miles of earthenware culverts and 25 miles of lumber, brick, and concrete culverts. The government now largely use iron culverts, with rolled girders and buckeled plates, from 4 to 35 feet span, the floor of the plates being filled with concrete. Mr. P. Scarr, one of the assis tant engineers, in a report bearing date 21st of December, 1890, reviews at length the condition of the roads in the southwestern division. He states that in the maintenance of existing roads there is great room for improvements. He directs especial attention to the condition of the metaled roads, mountain cuttings, drains, water tables, culverts, etc., as being badly in need of repair. The system adopted for maintaining the main trunk lines of roads in years past, when the whole traffic of

the interior passed over them, is not suitable for the extensive ramification of the minor roads which now carry the traffic to the railways and principal centers. Except in very few places the traffic is nothing like as heavy as that of the old trunk roads. The system in vogue then, of placing solitary men upon definite lengths of road, is out of place now. He says:

Then, under the very heavy and constant traffic, these men were regularly and continually employed in surface repairs, and were visited, if not at regular at least at frequent intervals. The officers had as a primary duty the maintenance of the main lines, so that they became so intimately acquainted with the lengths of road that they could estimate accurately the quantity of metal required on each and the number of men for each length of road. So that this system of having solitary men was perhaps the best that could be devised.

He says, further, that from the large extent of road comprised within each road district it is not possible for the officers to see these men often enough to enable them to judge whether they exert themselves or not. Although an enormous sum is paid away annually in maintenance wages, the maintenance of the work is by no means such as it should be. Value is not obtained for the money paid. Following upon this state of things the metaled lengths are imperfectly maintained, cuttings scoured by water, drains choked by vegetation, and culverts out of repair. It is impossible to lay to the charge of the officers these results. It would be going further into the mire for them to put on additional men to do the work. He proposes as a remedy the reduction of the number of the solitary men, and to form flying gangs who shall travel throughout the districts, each to have in a regular way a general circuit and perform all the necessary repairs periodically. He recommends that in forming these gangs the men at present employed should be absorbed as far as practicable, and that those remaining should act as watchmen over these gangs and receive a slight increase of pay above the others, and make them responsible for the proper working of the gang. By this means 50 per cent. more work, he says, could be done for the money now expended. Mr. Scarr states that in order to test this plan he placed a number of experienced officers in two districts, who have been at work several months with such favorable results that he decided to recommend its general adoption. Among the improvements brought about in the southwestern division by Assistant Engineer Scarr has been to make all parts of the road districts more accessible than formerly to headquarters, and at the same time keep in view the relative importance of the several roads and the facility afforded by the railway for getting at the points of destination. The Gundagai district has been considerably reduced by cutting off from it a number of roads lying to the east of it and throwing them into a new district of Cootamundra. This reduction amounts to 147 miles of road and an expenditure of $13,345 annually on scheduled roads. From Yass has been taken 102 miles of road, with an expenditure of $5,285; from Wagga district 55 miles, at an expenditure of $2,500. The Coota-

mundra district now embraces 125 miles of road at an expenditure of $30,275. The result of this rearrangement is shown in the following table:

District.	Officer.	Mileage.	Expenditure.
Goulburn	Mr. Kuwan	466	$39,245
Crookwell	Mr. Bawden	342	35,850
Yass	Mr. Nielley	449	30,500
Young	Mr. Moriarty	498	35,000
Gundagai	Mr. Frazer	335	91,450
Tumberumba	Mr. Allman	284	40,250
Wagga Wagga	Mr. Taylor	369	25,300
Albury	Mr. Smyth	646	45,300
Deniliquin	Mr. Beere	973	43,400
Hay	Mr. Chisholm	646	36,900
Cootamundra	Mr. Cox	425	30,525
Total		5,431	

Mr. Scarr says these tend to equalize both the mileage and the expenditure as much as possible, but it is to be remembered that the mere statement of mileage and expenditure must not be taken as complete evidence of the amount of work entailed upon each officer when comparing one district with another. Regard must be had in doing this to the nature of the country as to the facility of getting about, the importance of the roads and work to be supervised, and the relative position of the various roads. With the exception of the Gundagai district there is not any material difference in the amount of the expenditure. In this case the disproportion to the amount to be disbursed in the other districts is caused by the special grant of $60,000 for the road from Tumut to Kiandra, now in course of expenditure. This will be carried out during the present year, when the amount for that district will again fall to its normal amount. In the Albury district, where the works are important, the expenditure is slightly over the general average, but here a senior and experienced officer with two assistants are stationed.

EFFECT OF IMPROVED PUBLIC ROADS UPON LAND VALUES.

There can be no doubt that the improvement in the conditions of the roads from time to time has exercised a material influence upon the value of land throughout the country. In some districts as a consequence of this improvement it is found that produce (grain, for example) can be profitably carried considerable distances to market or to railway stations on the way to market.

In some cases maize is carted 20 to 30 miles by a good road to a railway and sent 250 miles to the metropolis, with a result remunertive to the grower, whilst in other districts where the soil is equally rich, the same grain can only be carted at a loss a less distance to a seaport 300 miles distant from the same market, in consequence of the unimproved condition of the roads.

A consequence of this is that much land which would otherwise

remain in a primitive state now is brought under cultivation and supports population enjoying the privileges of advanced civilization.

In other industries, too, the effect of the better state of the roads is felt. Mining, grazing, etc., are carried on to greater advantage and the benefit of this condition is felt.

G. W. GRIFFIN,
Consul.

UNITED STATES CONSULATE,
Sydney, March 12, 1891.

ROADS IN NEW SOUTH WALES.

[Inclosure in Consul Griffin's report.]

Under Secretary Barling to Consul Griffin.

PUBLIC WORKS DEPARTMENT,
Sydney, March 23, 1891.

SIR: With reference to your letter of the 26th ultimo, and to mine of the 6th instant, I am directed by the secretary for public works to forward herewith, in compliance with your request, a copy of the report of Mr. E. J. Statham, supervising engineer, No. 1 Roads Division, which it is hoped may prove of service for the purposes you require.

I have the honor to be, sir, your obedient servant,

J. BARLING,
Under Secretary,
Per D. A. W. T.

G. W. GRIFFIN, Esq.,
Consulate of the United States, Sydney.

GENERAL REPORT NO. 1 DIVISION.

To the COMMISSIONER AND ENGINEER-IN-CHIEF FOR ROADS:

SIR: In submitting my general report for the past half year I would explain in the first instance that delay in furnishing that report is due to a number of circumstances tending to bring about that result, principally the derangement of affairs consequent upon removal to Sydney, the necessity to personally visit portions of the new district with which I was unfamiliar, the disentanglement of business formerly in my charge now transferred to another division, the continued attention to those matters until such other division could be entirely taken up, the reorganization of my new district, and more especially the press of current business which has constantly demanded more than the regular office hours. My former division extended along the north coast from the Manning to the Queensland border, with Grafton as headquarters. It included the road districts of the Manning, Macleay, Bellinger, Grafton, Clarence, Lismore, Casino, and Tweed. A short experience of the division as thus arranged demonstrated the utter unworkableness of some of the districts, due to extension and ramification of new roads and development of fresh centers for settlement. In recognition of the necessity to meet the altered circumstances the Manning and Macleay have been relieved by the introduction of a new district, with Port Macquarie as its center. The Grafton district has been divided into two, designated Grafton and South Grafton; and Lismore has also been divided by making another, with Woodburn as headquarters. Under this new development Grafton,

never a convenient center, became more than ever unsuitable as divisional headquarters; and notwithstanding every effort vexatious delays have resulted, no doubt contributing to the discontent which has lately been the subject of inquiry. The same causes operating more or less over the whole colony, a thorough reorganization became a necessity, and under the new arrangement my division has been modified by a curtailment of its length on the coast, and the additions of a portion of the table land, bringing it in touch with the railway system and the principal postal routes, resulting in a vast improvement as respect the rapidity with which the business can be dispatched and any particular place visited.

As now constituted my division is designated No. 1, comprising the following districts in order of their latitude north of Sydney:

1, Armidale; 2, Bellinger; 3, Inverell; 4, Glen Innes; 5, South Grafton; 6, Grafton; 7, Maclean; 8, Woodburn; 9, Tenterfield; 10, Casino; 11, Lismore; 12, Tweed.

Armidale.—This district comprises the greater part of the southeastern portion of the table-land of New England, with a length of 607 miles of roads under immediate charge of Mr. S. A. Donnelly; in addition to the mileage mentioned the numerous works and bridges provided for by special grants make up an amount of business which characterizes this as one of the most important districts. The springing up of a township at Hillgrove mines, with a population of over 2,000, gave rise to the necessity for an entirely new road, on which heavy traffic had to be provided for and demanded a large share of the superintendent's time and attention; at the same place a problem presented itself as to the best means to provide access to the various workings down the Hillgrove gorge, which has a precipitous scarp extending to a depth of 1,600 feet; this has been solved by the laying out of a zigzag track some 2 miles in length, designed by Mr. Stilwell; a tender for its construction was accepted, but the contractor failed to take it up and fresh tenders have been ordered. Heavy traffic has also developed in connection with the railway stations at Uralla, Black Mountain, and Guyra, from each of which centers new roads radiate and are likely to become of rapidly increasing importance with the settlement of population on the rich basaltic country in the neighborhood of each of these stations. The road from Guyra to Tingha is becoming one of special importance as a route to the tin mines and has to carry very heavy traffic over a surface which presents long stretches of black basaltic soil, and porphyritic slopes of specially treacherous nature apt to become quagmire after any continuous wet weather, and only to be remedied by the most thorough construction. A great deal of good work has already been done on this road, but the expense of construction has necessarily been so heavy that the requirements of traffic are yet a long way from being provided for and occasional interruptions are only to be expected.

Easterly from Guyra a road suddenly assumed importance as the route to the mines at Kookrabooka and Bearhill.

Bellinger.—Here a set of conditions entirely different to the foregoing present themselves. The Bellinger and Nambucca rivers branching off near the coast, are crossed by ferries, those at Raleigh, South Arm, and Nambucca being of considerable width. There are other ferries higher up the river, namely, at Fernmount on the main arm of the Bellinger and at Congarini on the Nambucca. All these ferries are provided with large-sized punts worked by wire-rope gearing, which seem to thoroughly meet the requirements. The various branches of these rivers extend into rich brush land which has been brought under cultivation. The back country is ridgy and broken, but there are numerous pockets of brush land taken up for cultivation, and it has been necessary to connect these with various centers by roads for the most part in side cutting with numerous bridges and culverts. The grading and sectioning of these roads have taken up much time and called for the services of officers of special training and experience. The most important work in hand lately has been the ascent of the table land known as the Dorrigo Road (this is a rise of some 2,000 feet) by exceptionally heavy rock side cutting, the scarp being so precipitous in places

that cascades have threatened the stability of the roadway, and it has been necessary to control them by intercepting channels, leading into the more defined water courses which are provided with culverts. The works on this road are well advanced. The public are very impatient to have it opened, as it will give access to a large extent of rich land only needing this road to induce a population to settle on it.

North from the Bellinger much work has been done in opening up the road to Coff's Harbor, all through brush land, which has been taken up for settlement.

At Coff's Harbor the new jetty, now in course of construction, has given rise to the necessity for a new road about 1½ miles in length, to connect it with the through road between the Bellinger and the Clarence. This road is now well advanced, and will be ready before the jetty is finished. Between Coff's Harbor and Corindi has hitherto been in the Bellinger district, and has demanded a large share of attention; but this together with the road from Moonee to Sharpe's has now been transferred to the South Grafton district. Another important work in hand is the opening up of the road from Boat Harbor via Spickett's Creek to the Nambucca, which will greatly shorten the mail route, and afford direct communication between principal centers of population on the two rivers. There are heavy works on this road in crossing the mountainous divide between the rivers; the connection will probably be available for wheel traffic in a few months. Mr. Leith has pushed on these works energetically since he took charge.

Inverell.—This district has been under the charge of Mr. C. W. Jenkins since 15th October, between which time and the end of the year he reported seventeen contracts completed, seventeen others put in hand.

An exceedingly heavy traffic has to be dealt with on the main road from Inverell to Glen Innes all the way through black basaltic soil, every yard of which has to be metaled; the greater part of it has already been constructed, but being new work, it was terribly cut up during the late wet season, and has required much attention to put it in order again. There is a great sameness as regards the roads in this district, which are for the most part through rich basaltic soil, and consequently expensive to construct.

Glen Innes.—This district, in charge of Mr. Miller, is one in which black soil predominates, and metal construction is much in demand. From Glen Innes toward Grafton is one of the great mail routes of the colony, there being a daily mail between New England and the Clarence via the Newton Boyd road. Metaling is being carried on to a large extent. A great deal of construction has also been carried out on the road from Glen Innes to Red Range and Kings gate, where an agricultural population has settled; one of the principal works on this road is the bridge over the Mann River now nearing completion. Since the opening of the railway the road from Emmaville through Tent Hill to Deepwater has assumed great importance as being the principal traffic route from the rail at Deepwater to the tin mines on Vegetable Creek, and is one of the roads to be provided for from special general vote.

South Grafton.—This newly formed district was only taken up by Mr. Everett at the end of the year, and he has hardly had time to make himself acquainted with it. He has, however, found that the work before him is so onerous that he is unable to devote the necessary time to the exploration and grading for extension of roads in the Upper Orara, which is of the most urgent importance, having been so long awaiting the services of a competent man.

Mr. Everett's camp is now in that locality, and a surveyor has been sent to take up the work.

Coff's Harbor will be the outlet for this country as soon as the jetty is completed, and it is very necessary that these roads should be opened up in time.

Grafton.—The Newton Boyd road remains in Mr. Ranken's charge, and he has in hand the road to the Chandlers Creek gold field, which is heavy mountain cutting. Much the same description of work demands attention, and has been standing over a considerable time for some one at liberty to devote their time to it. The most

important work in hand is the Alumny Creek bridge, an iron structure with brick abutments, the contract for which has been recently let. At Carr's Creek some fascine work has been successfully carried out, where extensive slips have taken place. Another similar work is in progress on the river bank at McLachlan's, near Ulmarra, and is reported to be successful.

The steam ferry at Grafton and ferries at Ulmarra, Southampton, and Eatonswill are attached to this road district. There has been a certain amount of loss of time in transferring newly defined roads and works in hand to the lately formed South Grafton district, but the reorganization is now fairly well established, and Grafton requirements will receive the attention which their importance demands.

Maclean.—This district, which is in charge of Mr. F. G. Hurley, takes in the alluvial delta of the Clarence, a portion of the road Lawrence to Tenterfield, and Harwood to Woodburn, also the steam ferry at Harwood and hand ferries at North Arm, South Arm, Brushgrove, Bluff Point, Maclean, and Oyster Channel. Many of the roads in this district are over swamps and have consequently to be embanked. There are numerous timber bridges which require constant attention on account of the ravages of white ants.

Woodburn.—This district, lately cut off from Lismore, and now in charge of Mr. Crummer takes in the lower Richmond, and a strip along the coast as far as Byron Bay; here swamps have to be contended with on the low lands, and all else is the dense brush, which is rapidly disappearing with the advance of settlement.

There is an ever increasing demand for new roads, and the local officer has no light task in reporting on the various applications and setting out works in cases where funds have been provided. The brush hook and the level have to precede expenditure in nearly every instance, and the work of this district is consequently not to be judged either by the mileage or the amount of grants; and, though lowest on the list in both these respects, it is not by any means an unimportant one.

Tenterfield.—This district is in Mr. Williamson's charge; there are not so many roads as in some of the other large districts, but long distances have to be covered, and the traveling is more than average. Some of the works as at Acacia Creek and Rivertree are at a considerable distance from headquarters.

One of the most important works carried out lately is the descent of the tableland, between Undercliffe and Rivertree, where a road has been constructed with easy gradients, at an exceptionally small cost for such an undertaking.

The road from Tenterfield to Tabulam and Casino has assumed special importance since the opening of the railway, as it is the mail route to the Richmond river district and the Fairfield mines. There are a great many bridges in this district, many of them rather old, and needing careful looking after.

Casino—Is in Mr. Gracie's charge. It is one of the older districts, from which, in succession, the Tweed, Lismore, and Woodburn, have been cut off. There are many important works already carried out which have to be maintained, and lately there has been a great extension of settlement due to the resumption of leasehold areas, which will necessitate new roads, and the more thorough construction of those already opened. The richness of the land and extent of settlement both necessitate and justify a large expenditure in road construction.

Since the opening of the railway to Tenterfield, the mails formerly sent by sea, either by the direct boats, or those trading to the Clarence, are now forwarded by rail and coach, via Tabulan and Casino. In anticipation of such change, a direct road has been opened up, and a great deal of work has been done on it; but it passes over a considerable extent of black soil, and the construction is consequently expensive. Provision for this does not appear on the appended list, as the amount has not yet been determined; it, however is noted as one of the roads to be supplemented from the general vote.

Lismore district—Is in Mr. Allman's charge. The town of Lismore is the shipping port for a surrounding country, all of which is of the richest and most fertile descrip-

tion, and will for some time be the terminus of a new railway system. The development of sugar growing and extension of the dairying industry have given rise to the demand for a multiplicity of roads which might appear out of proportion to the size of the district; there can, however, be no question as to the necessity for their construction or the expediency of incurring the expense of so doing. There are numerous and important bridges in this district; some of these still in hand, or about to be commenced. It would unduly prolong this report to allude to these in detail.

The Tweed district—Is now in Mr. Scott's charge, but till recently has been under Mr. Morton, of whose services in connection with the district I can speak in the highest terms.

The district includes the watersheds of the Tweed and Brunswick, with the network of roads having their terminus at Byron Bay, where a jetty has been constructed and a shipping port established. The whole of this country is of exceptional fertility, and the difficulties of road construction are of no ordinary description.

To review the works already constructed, or to sketch those provided for, would involve so much detail that it appears to me it would now be out of place.

Bridge repairs.—The abundance and excellence of the timbers in these districts made timber bridge construction the rule, though some fine iron and composite structures have been erected. The climate is, however, unfavorable to their longevity, dry rot and white ant being very destructive; the white ant even attacks the punts, which are saturated with tar and always in water.

Repairing parties, under experienced, practical foremen, I find to be the most satisfactory way of dealing with these repairs, all material being supplied by contract.

Road districts and appropriations, 1891, *No.* 1 *division.*

Officer.	District.	No. of roads.	Mileage.	Amount.
Mr. Donnelly	Armidale	30	607	11, 486
Mr. Leith	Bellinger	16	252	7, 165
Mr. Jenkins	Inverell	16	401	14, 442
Mr. Miller	Glen Innes	17	369	8, 790
Mr. Everett	South Grafton	12	260	9, 807
Mr. Ranken	Grafton	8	204	7, 485
Mr. Hurley	Maclean	11	154	4, 980
Mr. Crummer	Woodburn	16	129	5, 235
Mr. Williamson	Tenterfield	14	390	8, 870
Mr. Gracie	Casino	13	291	9, 125
Mr. Allman	Lismore	41	321	12, 510
Mr. Scott	Tweed	19	209	12, 970
Total		213	3, 587	112, 865

NEWCASTLE.

REPORT BY COMMERCIAL AGENT BAGGS.

A report on the streets and roadways of this immediate district—and that is all the territory covered by this report—will hardly be instructive or of advantage, except comparatively.

The streets of the large towns and cities, ranging in population from 3,000 to 60,000 inhabitants, are invariably macadamized, as are also the country roads wherever an effort has been made to improve their original condition.

These city or town streets are formed by loosening the surface soil, spreading on 4 inches of sandstone ballast, then 2½ inches of blue metal, over which is spread a thin layer of sandy gravel. This is the ordinary

formation; but it makes a rough and uneven surface and is quickly cut in holes. On the principal thoroughfares the layer of blue metal is dipped in pitch and a thin coating of pitch over the top of this. This composition makes a good, smooth, hard road; but it needs constant repairing under heavy travel.

Owing to the want of courtesy shown by the Newcastle town clerk I am unable to give the cost of the original formation or of the repair of the city streets.

Owing, however, to the kindness of Mr. W. S. Wells, government engineer in charge of the roads and bridges of this district, exclusive of towns, I am enabled to furnish the following information:

The country roads in this (Newcastle) district (which extends about 50 miles to the south and about 10 miles to the north of this city along the coast and from the coast line inland a maximum distance of 60 miles and an average distance of 35 miles), are partly under the control of government engineers and partly under the control of road trusts. These road trusts are appointed by the government to expend the annual appropriations on the numerous byroads, which are only of local importance to farmers and pastoralists.

I append a list of roads under both, which shows the number of miles of different classes of roads cleared, formed, drained, and metaled up to date, also number of bridges and culverts erected.

Road in charge of engineers	miles..	157
Road in charge of trustees	do...	248
Road, metaled, graveled, and ballasted	do...	70
Road formed	do...	96½
Road cleared and partly drained	do...	123
Mountain passes and cuttings	do...	38
Bridges in district	number..	25
Culverts and pipe drains	do...	238

The following are the average prices paid for different classes of work in this district:

Clearing 66 feet wide, grubbed to 18 inches, at $3.90 per chain.

Ordinary formation, 30 feet wide, at $4.87 per chain.

Two and one-half inches blue metal spread 18 feet wide, at $2.42 per cubic yard.

Four inches sandstone ballast 18 feet wide, at $1.21 per cubic yard.

Side drains, average depth 2 feet in soil, at $2.42 per chain.

Mountain cuttings, 20 feet wide, from $15 to $100 per chain.

Owing to the fact that this country is as yet so thinly settled, the science of road-building has not reached that degree of perfection which would be of service to an older and more thickly populated community.

The greater portion of the roads are simply wagon tracks through the bush, absolutely impassable in wet weather. Wherever the travel warrants it, however, a good road is formed on the lines above laid down. Between town and town the roads are superior to the majority

of country roads in the United States, but once off the main road their superiority vanishes.

GEORGE T. BAGGS,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Newcastle, New South Wales, May 20, 1891.

FIJI.

REPORT BY COMMERCIAL AGENT ST. JOHN, OF LEVUKA.

Practically speaking, there are no roads in this colony that deserve the name.

Each magisterial district is at present making a dirt road by cutting two parallel ditches and throwing the dirt from them between the two, more to employ prison labor than to build roads that will be used for traffic or pleasure.

The main streets of both Suva and Levuka are made by prison labor of broken coral washed up by the sea, which is a very good material for the purpose, but it is not very lasting.

The traffic of the islands is all done by water; consequently roads are not required.

From inquiry I learn that there is not 50 miles of road in this colony.

Carriages or wagons are not used, except by a very few, in the towns of Suva and Levuka.

ANDREWS A. ST. JOHN,
Commercial Agent.

UNITED STATES COMMERCIAL AGENCY,
Levuka, February 16, 1891.

SUPPLEMENT.

SHEFFIELD.*

REPORT BY CONSUL FOLSOM.

CITY STREETS.

The material used for streets where the traffic is very heavy is granite; for medium traffic gritstone sets and wood blocks; and for very light traffic "tar macadam," *i. e.*, broken granite or limestone mixed with boiling pitch and tar.

Granite.—This is obtained from Leicestershire, Cumberland, and Dalbeattie in Scotland, and costs from 20*s.* 6*d.* ($4.99) to 24*s.* 6*d.* ($5.96) per ton. It is used in the form of sets, measuring 6 by 4, 6 by 3, 5 by 4, 5 by 3 inches and 4-inch cubes, the first two sizes being used for the heaviest traffic. The sets are laid on a bed of concrete formed of broken stone and sand, mixed either with Portland cement or hydraulic lias lime, and laid from 6 to 9 inches thick, according to the nature of the traffic. On the top of the concrete is spread a layer of fine shingle on which the sets are bedded; the joints are then partially filled with one-fourth-inch shingle, and filled up flush with hot asphalt (boiling pitch and tar). Value when laid, including concrete foundation, 13*s.* 6*d.* ($3.28) per superficial yard.

Gritstone sets.—These are obtained from quarries in the neighborhood and district. They are 10 inches deep and vary from about 6 to 10 inches wide. They cost from 15*s.* ($3.65) to 16*s.* ($3.89) per ton. No concrete foundation is used for this pavement, the sets being simply bedded on a layer of shingle and well beaten into place with a heavy "beetle." They are then grouted in the same way as the granite sets. Value when laid about 10*s.* ($2.43) per superficial yard.

Wood paving.—This consists of blocks of red deal 6 inches deep, 3 inches wide, and 9 inches long. Most of the wood paving in Sheffield has been put down in its natural state, but in the last lot the blocks were creosoted. The price of the blocks is about 1¼*d.* (2½ cents) each. A concrete foundation is formed similar to that described for granite paving, and over this a layer of sand is spread, on which the blocks are bedded. The end joints butt up against each other, but the side joints are kept the proper distance apart by means of three iron studs driven

* This report was received too late for insertion in its proper place.

into one of the sides of the block, making the joint three-eighths of an inch wide. The paving is then grouted up solid with boiling pitch and tar, or with liquid cement and sand. The latter method is now generally adopted. Value when laid, 12*s*. 6*d*. ($3.04) per superficial yard, including concrete foundation.

Tar macadam.—Very little of this form of paving is used near the center of the town. It consists of either furnace slag, limestone, or granite broken to a $1\frac{3}{4}$ or 2 inch gauge and mixed with boiling pitch and tar. It is laid on a foundation course of flat rubble stone set on edge. This foundation is well rolled with a heavy steam roller (10 tons) and the macadam is then spread over the pitching to such a thickness that after being rolled with the steam roller it will be 4 inches thick. A thin coating of tarred shingle or granite chippings about one-half-inch gauge is then spread on the surface which is again rolled. The rubble pitching costs from 1*s*. (24 cents) to 1*s*. 6*d*. (36 cents) per square yard. Slag tar macadam costs 2*s*. 3*d*. (55 cents) per square yard; limestone costs 2*s*. 6*d*. (61 cents) per square yard, and the granite costs 3*s*. (73 cents) per square yard.

COUNTRY ROADS OR HIGHWAYS.

These are all macadamized. A foundation course is laid as described for the tar macadam. The macadam consists chiefly of limestone which is obtained from quarries in North Derbyshire and conveyed direct on to the roads in carts. It costs about 7*s*. ($1.70) per cubic yard including carting and breaking, equal to about 2*s*. 9*d*. (67 cents) per superficial yard of finished roadway. Furnace slag is also used, and is obtained from the iron works and blast furnaces in the neighborhood. It is delivered at the railway stations at 3*s*. (73 cents) per ton, breaking 2*s*. 1*d*. (51 cents) per ton extra, finished 1*s*. 6*d*. (36 cents) per superficial yard. Granite macadam is also used in suburban roads. It comes chiefly from Leicestershire and costs, delivered at the stations, 9*s*. 9*d*. ($2.37) to 10*s*. 6*d*. ($2.55) per ton broken. Finished roadway 2*s*. 3*d*. (55 cents) per superficial yard.

On a few crossroads and country lanes gannister is used, but only where the traffic is exceedingly light. Costs about 1*s*. (24 cents) per superficial yards.

The macadam of whatever material it may be is spread over the road to the proper contour and covered with a layer of small limestone chips, or, in the more remote roads, with clean roads sweepings. It is then watered and rolled either with the steam roller or a heavy two-horse roller.

GENERAL.

The first cost of public roads, and also the cost of maintenance is paid out of the public rates, the expense being thus borne by the whole of the rate-payers. Where the road is a private one, having been laid out and made by individual owners, then the expense of paving, etc.,

done by the corporation prior to taking it over as a public road, is divided amongst the property owners on each side of the road in proportion to the length of their respective frontages.

A well-made road undoubtedly enhances the value of the adjoining land or property, although it is difficult to say to what extent. In the case of cottage property adjoining a private street the effect of making good the street and "dedicating" it to the public frequently is to raise the rentals.

I am indebted to Charles F. Wike, esq., borough surveyor, Sheffield, for the foregoing facts in relation to the construction of pavements and roadways in and about Sheffield.

The following paper by Mr. Edgar S. Saunders, C. E., assistant borough surveyor, Sheffield, has been kindly furnished me by him, with drawings illustrating the manner in which the best pavements and roads are constructed:

PAVEMENTS AND ROADWAYS.

Before deciding of what material a roadway is to be made there must be considered the class of trade of the town, whether a manufacturing, agricultural, or seaside town, etc., and also (and more important than the foregoing), the gradient of the road or street in question. A good roadway should be:

(1) Durable and requiring little repairing.

(2) Safe with a minimum of traction, and yet with sufficient foothold for horses, and with as little possible jolting to the traffic.

(3) Laid to such a cross-section as will throw off the rain water at once.

(4) Easy to cleanse, nonabsorbent of moisture, and make a minimum of mud and dust.

(5) And it must, above all things, have a good and firm foundation; for it must not be forgotten that it is the foundation that carries the weight, and that the superincumbent pavement is really only the means of transferring the weight of the traffic to these foundations, and that, however durable the pavement may be, it is bound to require renewal, whereas the foundations should be permanent.

The wear of the surface of a road is generally estimated to be due to the action of the horses' feet to the extent of two-thirds of the total wear, the remaining one-third being due to atmospheric and other causes.

It is impossible to cleanse a roadway too much; not only does it add to the life of the sets (of whatever material they may be), but it is also a great boon to the horses which have to traverse them, the difference in traction between a paved roadway well swept and in good order, and one covered with mud, being sometimes as much as 50 per cent.

Considering safety in traveling only, it is stated that a horse will travel the furthest without falling, on gritstone sets, wood pavement ranking second, asphalt (natural) third, and granite last of all; but it must not be therefore necessarily assumed that gritstone has a superiority over wood or the latter over granite, since, as mentioned at first, there has to be considered the gradient of the street and therefore the foothold required.

A most important consideration is to give a proper contour to the carriage way. This is mainly dependent on the longitudinal gradient of the road, or street, in question, it being necessary that a more convex contour should be given to a level, or flat, street than to one with a sharp incline. It is also dependent upon the material used for paving, more camber being needed for gritstone than granite; asphalt pavement requires the least, as there is a minimum amount of friction; then comes wood, next

granite, and lastly gritstone sets. (See Appendices B C D and E.) It is therefore impossible to give a fixed rule for this, but it may be safely assumed that the variation should extend from about 1 in 30 to about 1 in 40, according to the gradient of the road and the material used.

It has been a considerably discussed question as to what should be the actual form of the cross-section of the roadway, whether circular, parabolic, or two straight lines connected tangentially by means of a central curve, and probably in the majority of cases it will be found that the latter is the easiest for average traffic, but if adopted, the two side lines should not, in practice, be perfectly straight, but should have a slight camber given to them, as otherwise there might be a tendency in the sides of the carriage way to wear hollow. (See Appendices B, C, D, and E.)

The usual materials at the paver's disposal, are: (1) Granite, (2) wood, (3) asphalt, (4) gritstone. The last, though not in very frequent use, is, if of proper grit, a valuable material, particularly in towns built in hilly countries where granite or wood would be dangerous to traffic, and where the traffic is not too great.

It is now proposed to describe the manner of utilizing the foregoing materials as pavements for the carriage ways of large towns.

Granite sets.—Granite sets well laid undoubtedly form the most durable of pavements, being hard, cleanly, lasting, nonabsorbent, and making little dirt or dust, their only objection being that they are somewhat noisy and (in certain conditions of the atmosphere) slippery, although this depends to a great extent upon the kind of granite used. Whatever the class of granite, it is essential that it be well squared and dressed before it is laid. The sizes of the sets in most general use are: 7 by 4 inches, 7 by 3 inches, 6 by 4 inches, 6 by 3 inches, 5 by 3 inches, and 4-inch cubes.

The 5 by 3 inch and the 4-inch cubes should not be used where the traffic is very heavy, but are suitable for streets having a medium tonnage passing over them. They are, of course, lighter, and therefore easier to handle than the deeper and broader sets, and so a pavement constructed with them is laid rather more rapidly, which may be sometimes advantageous. The 6 by 4 inch and the 6 by 3 inch are the sizes of sets most frequently employed. The former, however, should not be used on a street having much incline, as being 1 inch wider than the 6 by 3 inch sets, they do not afford so good a foothold for horses. The sets should be dressed truly square, with the sides and ends perpendicular to the face and bed, so that the areas of the two latter are equal. This is most important, as not only does it insure stability and firmness to the pavement, each set having its utmost area of base, but also, if the pavement requires repairing and resetting in the course of time, it allows the sets to be reversed, *i. e.*, the bed may be turned uppermost so as to form the face, which is an economical practice well worth consideration.

If the sides be not truly square to the face but incline inwards, then the base is less in area than the face, and the condition of the set is one of perpetual unstable equilibrium; nor can the sets be used over again as suggested above, as the top joints could not then be made good since they would be wider than the bottom ones; for this reason also the sets must not incline outwards from the face to the bed. Care must also be taken to reject, or to have redressed, any sets with much belly on their sides, that is to say, sets whose sides instead of being plane surfaces are more or less spherical. It is sometimes impossible to altogether do away with this objectionable feature on account of the difficulty of working some of the granites, but, as far as possible, it ought not to exist, as it is impossible to grout satisfactorily such a joint as will be found by the contact of one set with another one of which is "bellied" on the side of contact; it also spoils the regularity of the lines of the joint of the pavement, which should be exactly parallel to each other, and strictly at right angles to the curb line of the road or street.

With regard to the face an exact uniformity of surface is not a necessity; indeed it is requisite that there should be a certain amount of roughness to obviate slipperiness, but large or unsightly excrescences should not be allowed.

In resetting a street already paved with granite the old sets must be taken up and carefully squared and dressed in the manner above described, the sets being reversed, *i. e.*, the old bed made the new face if the original quality of dressing will allow it; if not, a new face must be made which will, of course, reduce the depth.

The ends of the sets as before stated should always be dressed so as to be perpendicular to the face, and to be truly planed.

In taking out the excavation preparatory to paving a road with granite sets, and which road—supposing, for an instance—has hitherto not been formed with this material, the formation level should be made at a depth sufficient to receive the depth of the sets proposed to be used, together with about 1 inch for bedding material, and about 9 inches for concrete, which latter thickness is, as a rule, the most useful one for the foundation course. Thus, suppose the size of the sets to be used is 6 by 3 inches, then the depth of the excavation will be:

	Inches.
Depth of sets	6
Bedding material	1
Concrete foundation	9
Total	16

If, however, the ground at this depth be found to be boggy, soft, or at all unreliable, then a further depth should be excavated, and additional concrete put in; and conversely, if, as is sometimes the case, in old macadamized roads, which consist, by means of numerous old coverings, of great thickness of metal, it be found that there is a good foundation before getting to the depth of the 9 inches for concrete, then a less thickness for the latter material will suffice, thereby effecting economy with equal strength. In any case the formation level should correspond in camber with the proposed finished surface of the road, so as to insure uniformity of thickness of foundation course.

The binding element of the concrete must be either hydraulic lias lime or Portland cement, the former being the most generally used, though in several towns the latter material is almost exclusively used for this purpose. Given good materials, the following are suitable proportions:

LIME CONCRETE.

	Measures.
Broken stone	3½
Clean sand	1½
Hydraulic lias lime	1

CEMENT CONCRETE.

Broken stone	3½
Clean sand	2½
Portland cement	1

The stone should be clean, hard, and angular in shape, the latter qualification being very necessary, as stones having a rounded surface will not bond well together so as to form a homogeneous mass; care must also be taken to exclude all clay dirt or other foreign material which would tend to prevent thorough cohesion.

The sand must be clean and sharp and, as a rule, good river sand is preferable to all other; it must also, similarly to broken stone, be free from all dirt of any kind. In towns in which there are large iron works "slag" dust has been used for concrete in place of sand, but though more economical in some cases (on account of being local), and though it forms a good enough material for the purpose if clean, its use can not be generally recommended on account of dirt being very frequently intermixed. The lime should be hydraulic blue lias—lime from the hardest and lowest beds of the lias formation.

Should cement be used it must be well burned Portland cement of the best quality, free from all dirt, or other foreign substance, and slow setting with a gray color when gauged and air dried. It should be of not less than 114 pounds weight to the bushel, and must be sufficiently fine so that a portion being sifted through a wire sieve of 2,500 meshes to the square inch there must not be left a residue of more than 10 per cent. in weight.

Briquettes of neat cement should be made in the proportion of 7 ounces of water to 40 ounces of cement and should remain one day in the air, and then be placed for 6 days in water, after the expiration of which time they must be tested in a proper cement testing machine, and should sustain a tensile strain of 350 pounds to the square inch.

The concrete must be mixed upon a low movable platform capable of being shifted along as the work proceeds.

The three materials, stone, sand, and lime, or cement, as the case may be, should be measured separately, the stone then being placed by itself on the platform and the sand and lime (or cement) thoroughly incorporated with each other. The two latter must then be placed over the broken stone, and the whole mass must be completely turned over twice, so that the whole of the materials may be thoroughly intermixed. Water should then be added from a watering can provided with a rose, and the materials well turned over again for a third time; the concrete must then be immediately shoveled up into barrows, and wheeled away on to the formation surface, giving by the action of loading the barrows another turn over. Too much importance can not be attached to the necessity of thorough and complete incorporation of the materials, and as this can only be obtained by means of careful and repeated turnings over it is necessary that this be done in a most careful and complete manner. Concrete is, after all, but like masonry—stones and mortar—and just as the blocks of stone of the latter should be surrounded on all their joints with the mortar, so also the broken stone in concrete must, each individually, be surrounded with a perfect coating of the lime, or cement and sand. Another point to carefully note is the quantity of water used. The workman is sometimes to blame in this particular, as he often adds more water than is sufficient to release the chemical action of the lime or cement, as the case may be. Too much water greatly weakens the strength of the concrete and only so much should be used as will completely wet, but not drench, the material on the platform. The acting of the turning over, loading into the barrows, placing in situ, and ramming will, if properly done, completely wet the whole of the material, though possibly it might seem too dry immediately after the watering.

Before the concrete is placed in position levels must be fixed for it so as to insure uniformity of thickness and camber. These levels should consist of iron pegs not less than 18 inches long and placed longitudinally at short distances, the number across the road depending on the width of the carriage way; the tops of these pegs are to be carefully boned into the required gradient, and also to the proper camber of the transverse section (it must not be forgotten that the formation surface should have been first formed to the proper contour); 9 inches upwards from the ground should then be marked on the pegs, if the concrete is to be of that thickness, and either that portion or the remaining top inches is to be chalked or painted over so that the finished surface of the concrete may be clearly defined. This setting out of the levels requires careful attention, and must be well looked after. The iron pegs being properly fixed, and the concrete being thoroughly mixed, as before described, and loaded into the barrows, it must be wheeled from the mixing platform, deposited in position, and be well rammed with heavy wooden rammers, until its thickness is uniform with the chalked pegs. Thorough ramming is very essential, not only to consolidate the concrete but also to work up a smooth finished surface. The concrete must then be allowed to thorougly set before any further steps are taken, which length of time will depend somewhat upon the quality of the lime and cement.

The next process is to cover the concrete with bedding material for the sets. This may consist of either coarse sand or very fine gravel, and in towns where there are works, furnace ashes form a very suitable and economical material. Whatever is used it should be spread over the concrete to a depth of about 1 inch, so that the more or less irregular beds of the sets may have a firm seat over the whole of their area. The sets are then to be laid in rows with their lengths at right angles to the direction of the street. They must break joint properly, with as much overlap as possible, and must be well and solidly rammed. The channels, next to the curb, may be formed of two or more rows of sets placed at right angles to the other sets, *i. e.*, parallel in their length to the direction of the street, but a better channel is made by using slabs of granite 15 inches wide and of a depth equal to the sets used, the joints being truly square, and the surface dressed off to a plane surface. This latter plan enables the rain water to flow much quicker to the gullies, particularly in a flat street, there being less friction than if sets are used, being less joints, and a more even surface. In any case the channels should be laid about 4 inches below the level of the curb, and one-quarter inch below the sets. (See Appendix B.)

Should the gradient of the road be steep it is a good plan to lay a "wheeler" course, that is to say, a row of granite slabs, similar to those forming the channels, should be laid on the left-hand side of the road going up hill, and at a distance apart from the channel, center to center, equal to the average gauge of the wheels of the traffic which will most frequently use the road. These are of very great service to heavy traffic on a steep gradient, acting, in fact, as tram lines, affording as they do the minimum of traction to the wheels of the vehicles, while the sets between them afford a good foothold for the horses.

The sets being laid they have now to be grouted. Clean gravel, small stones, or fine slag (which forms a most suitable material if cheaply obtainable), not exceeding a quarter-inch gauge, must be spread over the top of the sets and be repeatedly swept over the surface until the joints are filled to rather more than half their depth, and, if necessary, a "cramming" iron must be used to wedge the shingle firmly into the joints, care being taken not to disturb their true line. The joints must then be grouted, thoroughly flush, with boiling pitch and tar, and it must be understood that this grouting should be really thorough and complete.

It is impossible to give the exact proportions for the mixing of the pitch and tar necessary for the final grouting, as the latter varies so much in its consistency; it is generally obtained from the gas works of the town, and should be as pure as possible. The pitch most suitable for use is that known as "medium hard," and should be of such a nature as to be softened after being immersed 5 minutes in water heated to a temperature of about 60° C. (140° F.). The two materials must be placed in a tar pan and well boiled, one man being constantly employed in turning the mixture over with a ladle, when the boiling point has been reached, and continuing to do so until the contents begin to settle, when, as a rule, it is ready for use; this is necessary to prevent boiling over which might result in the whole panfull catching fire. It must be boiled so that a cake of it when cool and set must be tough and not too brittle, but with a slight and only slight amount of elasticity. If it be too brittle when set the vibrations of the traffic may crack it and loosen it from the sets, which it will not therefore properly cement together; if it be too elastic it will in hot weather work out of the joints and get soft, thereby not giving the necessary support to the stones. Proper grouting is therefore a very important adjunct to good carriage-way paving.

The last operation concludes the work of laying granite pavement, which pavement is, on the whole, probably the most useful, durable, and, in the end, economical pavement that can be adopted for the carriage ways of large cities or towns.

Appendix B at the end of this pamphlet shows a suggested cross section of a roadway paved with granite sets. The footpaths have been added in this and the succeeding appendices, merely in order to complete the transverse section of the whole road. The cross fall of the carriage way, shown in the appendices, is of course not

arbitrary, since, as before explained, this will vary in accordance with the gradient of the street.

Wood pavement.—The advantages of wood pavement are: (1) It is the quietest of all pavements. (2) It gives a minimum of traction, excepting asphalt. (3) It is very clean, as if properly formed it should make no dirt. (4) If a horse fall on it he can, it is said, rise easier than on granite or asphalt.

The objections are: (1) It absorbs moisture to a somewhat great extent. (2) The wood is liable to swell and sometimes forces up the curbs and footway. (3) It can not well be used on a steeper gradient than 1 in 20 at the most.

It is not as durable as granite, and therefore, though not costing quite so much in the first instance, it really is dearer than the latter, as it requires more frequent renewal.

The best wood to use for the purpose is Baltic red timber, or yellow deal; and must be thoroughly sound and well seasoned, especially free from sap, and also from all shakes, knots, or other imperfections. The blocks, which must be cut so as to have the fiber upwards, should be 6 inches deep by 3 inches in width, and 9 inches in length. The blocks are sometimes creosoted, in which case 1 cubic foot of wood should absorb about 8 to 9 pounds of creosote. If the wood used be of really good quality, and be carefully laid with the fiber vertical on a good concrete foundation, such as described for granite paving, and be thoroughly grouted, this class of pavement will wear for a considerable time, its life with average traffic, and with, of course, needful repairs, being about 9 or 10 years. It is especially useful when laid in places where it is necessary to subdue the noise of the traffic, such as in front of a hospital.

With regard to the method of laying it is unnecessary to mention again the concrete foundation, as the method before described for granite pavement applies equally to wood, whether in materials, manner of mixing, or mode of laying. The concrete laid, and having become thoroughly set, a thin covering or bedding of sand should be spread over the surface, and on this the wood blocks, carefully selected, should be set with their lengths at right angles to the curb line, and having their ends in contact.

The setting should not commence close to the channel, as in the case of granite pavement, but about 7 to 9 inches from it, this space being filled up the last thing; this allows for any swelling of the wood, and will help to counteract the pressure against the channels and curbs, and lessen the tendency to force them up. An "expansion" joint is also sometimes left near the curb, but this is very unsightly and is of questionable utility. The side joints, that is to say, the joints running across the street and parallel to the length of the blocks, must be kept apart so as to afford a foothold for the horses. The width of these joints should be about three-eighths of an inch, and they may be obtained either by using laths of this width placed between each row and afterwards removed for the grouting, or, what is better, by means of three iron studs, having square heads three-eighths of an inch thick, and driven home into the sides of the blocks so as to form an equilateral triangle. This latter method has great advantages over the former and is the one most commonly adopted. When the laths are removed for the grouting the blocks are very liable to be more or less shifted from their position on account of the workmen walking over them, and other causes, and always require some adjusting and putting into proper line before the final grouting takes place. and even then it is very difficult to get a truly uniform joint the whole width of the carriage way. By utilizing the iron studs, on the contrary, each block may be at once firmly placed against its longitudinal neighbor, and there is no danger of any movement taking place prior to the grouting. Gravel or shingle three-eighths inches gauge is then sometimes swept over the surface of the pavement so as to partially fill up the joints (in a similar manner described for granite paving), but it is a question whether this should be requisite when the iron studs are used, as these should insure thorough stability and solidity to the block. When

the laths are used it is of course necessary to have the shingle. The grout itself may consist of either Portland cement and sand or pitch and tar, as specified for granite pavement, or may be, and this is probably the best, a combination of both methods.

The pitch and tar, well and properly boiled and of good quality, as before described, should be poured into the joints of the pavement until they are filled to about one-third their depth; this should be allowed to get cool and set, after which a grouting, consisting of Portland cement and clean sharp sand, each of such quality as hereinbefore detailed, and in the proportion of one part of cement to one and a half parts of sand (or even only one part of sand if the cement be at all poor), must be poured in so as to completely fill all the joints flush with the surface of the blocks. The whole surface of the carriage way is then to receive a coating about half an inch thick of fine gravel or small, clean chippings.

The channels should be formed by means of two rows of blocks set with their lengths parallel to the direction of the street, and laid 4 inches below the curb and flush with the main blocks. (See Appendix C.)

Asphalt pavement.—Asphalt pavements are not greatly in use, and it is a material which can not be generally advocated as useful for the pavements of carriage ways of large cities, its great objection being its extreme slipperiness and also the great difficulty of stopping or starting a horse drawing a burden on account of the almost non-existence of a foothold. The chief points in its favor are that it is very noiseless though not so much so as wood; there is very little traction, no shaking or vibration in driving over it; it is very easily cleansed, and is quickly laid. It is, however, impossible to use it where there is anything like a gradient, and also it can not be laid in wet weather.

The asphalt itself consists of carbonate of lime and bitumen, chemically combined in somewhat varying proportions, and should have a fine and uniform grain when broken. For laying carriage ways the limestone should contain about 10 per cent. of bitumen. Asphalt pavement has one particularity peculiar to itself, and thereby differing from all other pavements, and that is that owing to its elastic nature, which is its great feature, and which lasts for a long time, it does not actually begin to wear until it has been laid for a considerable period, although its actual thickness will be reduced.

It is to be laid on a concrete foundation as previously described, and which must, and this is more important in this than in all other kinds of superincumbent pavement, be thoroughly set and perfectly dry, as otherwise the asphalt will be liable to "blow." Cement concrete is better than lime concrete for the foundation of this pavement.

The rock asphalt must be of the purest quality, and be of such chemical analysis as before mentioned; after being broken to small lumps it must be thoroughly pulverized in a proper disintegrator. It should then be heated on plates to such a temperature as may be necessary to wholly get rid of all moisture, this temperature varying according to the nature of the material, but generally about 220° to 270°. It must be immediately and carefully carried to the road in covered vehicles of iron so as to lose as little heat as possible, and to be spread over the surface of the concrete foundation to a depth of 3 inches, which will be reduced, after ramming, to nearly 2 inches. It must then be carefully raked and spread, so as to ensure thorough regularity of depth and evenness of surface, and be well rammed with heated, to prevent sticking, iron, of about 10 pounds weight, the ramming being done lightly at first and heavier afterwards.

When finished the pavement, if properly done, should present a perfectly uniform and pleasing appearance. It must be allowed to cool and become thoroughly consolidated before allowing traffic to pass over it. The slipperiness, its great drawback, may be temporarily remedied by strewing fine shingle or sand over the surface, but this tends to wear it out, as it breaks the skin and lets in the moisture; it also makes the surface muddy and dirty.

The channels should be formed of either granite sets laid in rows about four in number and parallel to the curb line, or with granite slabs 15 inches wide and 6 inches deep, as described hereinbefore. In any case the channels should be laid about half an inch below the level of the asphalt and 4 inches below the curb. On the whole this kind of pavement can not be generally recommended for the paving of towns, being dangerous to traffic and not sufficiently lasting where the traffic is heavy; its advantage being its quietude, easiness of traction, imperviousness to moisture, and the ease with which it is cleansed. (See Appendix D.)

Gritstone sets.—Sets formed of gritstone are used to a large extent in those towns or cities, near which there are suitable quarries. It is a material having many advantages for the pavement of carriage ways, but it can not be said to be durable where there is great traffic, and this is its great drawback, as, of necessity, this means frequent repairing and renewal, which eventually causes it to be classed as an expensive pavement. For roads, where the traffic is moderate, or where the gradient precludes wood and asphalt, and makes even granite dangerous, gritstone sets are very useful and may be adopted with success. They are not slippery, do not present too much traction, afford good foothold to horses, and are speedily laid. This pavement is not so noisy as granite, and is, in the first instance, considerably less expensive (always supposing that the requisite quarries are more or less in the locality) but as a durable, useful, pavement it can not be compared with the latter, nor is it, as stated above, cheaper in the end.

The stone should be from a good gritstone quarry and be composed of a hard, brown, or yellowish brown, grit not too close. Very fine grits should be avoided, as these do not possess the necessary wearing properties.

The sets must be cut so that the grain of the stone is parallel to the length of the set, and at right angles to its width. This is of the utmost importance as sets with their grain cut this way will wear much longer than with the grains parallel to the width of the set, so that in case of two sets being placed side by side in the pavement one cut correctly and the other incorrectly, it would follow that the wrongly cut one would the soonest show wear, and there would be a "puddle hole" in the street. The reason why the wrongly cut sets wear away the quickest is because the grain being parallel to the width of the stone it is in the line of traffic, to which it therefore renders little resistance, and is soon overcome by it. The sets may vary in depth from 8 to 10 inches; the latter being the most useful, and though costing more at first are the most economical, as when they are worn down about 2 inches and have thereby got irregular and into holes, (and it may here be remarked the worst feature of this pavement is that however uniform in quality all the sets may be, and however uniformly and properly cut, it will always, unless the traffic be a very light, wear irregularly which is probably due to the traffic more or less confined to certain lines which will always soon tell on gritstone), the 10-inch sets may be taken up, redressed and squared and then reset, whereas the 8-inch sets are, as a rule, too much worn and knocked about so that they are only worth using for bowlder pavement. The 10-inch sets, being of course heavier than the 8-inch, require more handling and can not be set as quickly as the latter.

Whatever the depth, the width should not be less than 5 nor more than 7 inches, and the length should be from 7 to 10 inches. It is not necessary that the pavement of the street should consist of sets of one width, such as is adopted for granite sets, as a horse can obtain foothold on the stone itself, whereas in granite paving the foot of the horse, if placed on the center of a set, almost invariably slips back until it reaches the joint. For a steep gradient, however, the narrower gritstone sets should be used, the broader ones being kept for flat streets.

The sets must be dressed truly square through their whole depth, so as to insure an area of base equal to that of the face. No excresences on the sides or end joints must be permitted, it being necessary that all the joints should be truly perpendicular to the face and parallel to each other. The face of the sets may be left somewhat rough, as any undue roughness will soon be worn off by the traffic.

This class of sets having—compared with granite or wood—a large area of base, it is not necessary to have a concrete foundation, provided that the ground at the formation level be found to be hard and solid, and provided, also, that the traffic to pass over is not too heavy (and it must be remembered that this pavement is not suitable where the traffic is great). If, however, the ground, or any part thereof, be found to be soft or unreliable further excavation must be made and lias lime concrete filled in, as specified before for the granite paving. On the surface of the foundation, whether natural or concrete, a layer of clean sand or, if cheaply procurable, furnace ashes is to be spread about 1 inch thick, on which the sets are to be laid in lines, with their length at right angles to the direction of the street, and properly coursed in single courses. They must be set with an overlap of at least 3 inches at the joints and, as before mentioned, so that the natural grain of the stone is parallel to its length. Each stone when set should be well and solidly rammed with a heavy "beetle," care being taken to preserve the proper camber.

The sets must then be grouted in a manner similar to that described for granite paving, *i. e.*, one fourth inch gravel, or slag, must be swept over the surface, using a "cramming iron" if necessary until the joints are about half full, after which they must be flushed up solid with boiling pitch and tar as before detailed. The channels may be formed either by simply the prolongation of the rows of sets up to the curb or may consist of gritstone slabs, similar to the granite one mentioned for granite paving; the latter method is probably the best as the slabs offer less resistance to the surface water; they should measure 15 inches wide by 8 to 10 inches deep, and must be set, as in the case of the other pavements, 4 inches below the curb and one-fourth inch below the sets.

In many towns this class of pavement is successfully used, but too much must not be expected from it; it has not the wear and solidity of granite, and can not be used economically where the traffic is very heavy, but for streets with comparative steep gradients and moderate traffic, gritstone sets form a most useful material. (Appendix E shows this class of pavement.)

There has now been described in detail the four materials mentioned at the commencement of this essay, viz, granite, wood, asphalt, and gritstone, but it should be clearly understood that whatever material be adopted the success of a pavement consists in the manner in which the material is dressed, the way it is laid and grouted, and in having a good firm foundation; in other words the points to be considered are: (1) Suitable material of the best quality. (2) Material to be properly "got up" and prepared. (3) The foundation must be thoroughly hard and firm. (4) There must be skillful laying and perfect ramming. (5) The grouting must be of good and suitable composition, and liberally filled into the joints.

The last stipulation does not, of course, apply to asphalt pavement.

The proper construction of crossings at the junction of new streets is of great importance, and is not always an easy undertaking, great care being required to set out the proper levels, which must be strictly adhered to in the laying. The center line of each road must bone through, each central line coinciding in level at the point of intersection, the camber of the main carriage way working flat as the center of the crossroad is reached, so that at that point there will be no camber; this is to be done by keeping up the level of the line of the channels of the main road as the center of the crossroad is approached, which will cause the center of the two roads to be the highest point of the crossing, and also cause the two crossings at the ends of the secondary street to have a suitable camber, so that all the surface water will fall off easily into the proper channels and there will be no jolting or hindrance to the traffic. The crossings at each end of the side street should have a number of lines of granite slabs, sometimes called "plodders," laid parallel to the direction of the main street, and separated from each other by three or four rows of granite sets. The plodders should be 12 inches wide and equal in depth to that of the sets used; they are a great convenience to pedestrian traffic, as they are much easier and more pleasant to walk upon than the sets. (See Appendices F and G).

The sets forming the large crossing may either be laid in the same manner and direction as they are in the main carriage way, that is to say, in regular rows with their lengths at right angles to the line of the street (see Appendix F), or, what is much better, may be placed diagonally (see Appendix G). This latter system affords a good foothold for horses in turning the corners and prevents the danger of slipping, which is very liable to occur when a horse is pulling along the length of the sets. The ends of the diagonal sets, where they abut upon the straight sets, at each of the four sides of the crossing, must be properly cut and leveled off so as to insure a good joint, and where they meet each other at the two center lines they must form a true "herring-bone" joint, which may be either single or double, the former being the most generally adopted. (Appendix G shows the latter.)

The circular channels, connecting the channels of the two streets, are to be truly cut to the proper radius, bone through, and be carefully laid.

The footpaths in Appendices F and G are shown merely to complete the plans of the streets.

For the surface drainage of the carriage way, and also to receive the rain water off the causeway, gullies must be provided. These should be of cast-iron, properly trapped and connected to the sewer with 6-inch glazed stoneware socket pipes, having their joints filled with puddled clay, and a puddle band 5 inches thick around each socket joint. The distance apart of the gullies mey be somewhat greater on a steep road than on a flat one, and if the longitudinal section of the carriage way be a dead level it will be necessary to give an artificial fall in the channel, that is to say, the point in the channels half way between two gullies must be kept higher than the level of the channels at the gullies, but this must be avoided as much as possible as it breaks the uniformity of the cross fall of the road. In all cases, however, thorough surface drainage is necessary, both to lengthen the life of the pavement and to render the traffic, whether vehicular or pedestrian, safe and pleasant. As mentioned at the commencement proper cleansing is also an important adjunct.

Great advances have been made during recent years in the quality and workmanship of the carriage-way pavements of our large towns, and there is no doubt that as "experientia docet," there is to be still further improvement made before the highest point of perfection is gained.

Prices have been purposely omitted in this essay, as the cost of pavements depends so much on the position of the towns, its proximity to granite, or other quarries, the means of transport to it by rail, or canal, that it is impossible to give satisfactorily an idea of its value.

Granite pavement.—As a rule the most suitable granite for paving are syenites, or syenitic granite. The syenite consists of quartz, feldspar, and hornblende, the latter taking the place of mica in the ordinary granite; syenitic granite consists of all the four constituents. They are generally obtained from quarries in Leicestershire, Cumberland, Guernsey, and Jersey; the material from the latter two places is, however, apt to wear slippery. Penmaenmaur stone from North Wales, a kind of trap-rock, is likewise used, and also different granites from Ireland and Scotland, such as (from the last-named country) Aberdeen and Dalbeattie.

Wood pavement.—Beech wood has been employed for wood paving, but is dearer than the red wood, or yellow deal, which should always be carefully cut from sound specimens of the northern pine.

Asphalt pavement.—Instead of the rock asphalt being pulverized and heated, as described in the foregoing paper, it is sometimes mixed with small hard grit and melted down to a liquid state, a small amount of bitumen being added to assist the process. It is then removed from the boiling pans in ladles and poured over the concrete foundations, brought up to a regular surface by rubbers and covered, while soft, with fine shingle. This method, however, is not so good as the compressed pavement.

Gritstone sets.—A great quantity of the gritstone used for paving comes from Yorkshire and Lancashire.

Weights of materials for carriage-way pavements and the areas they will cover.

[A cubic foot of granite weighs 164 to 180 pounds.]

A ton of granite sets—	Sq. yards.
7 by 4 inches will cover about	3
6 by 4 inches will cover about	3¾
6 by 3 inches will cover about	4
5 by 3 inches will cover about	4½
4 by 4 inches (cubes) will cover about	5

A cubic foot of red deal weighs about 43 pounds; 1,000 wood blocks 6 by 3 by 9 inches set with three-eighths of an inch cross joint will cover about 22¾ square yards, it taking about 44 blocks to 1 yard.

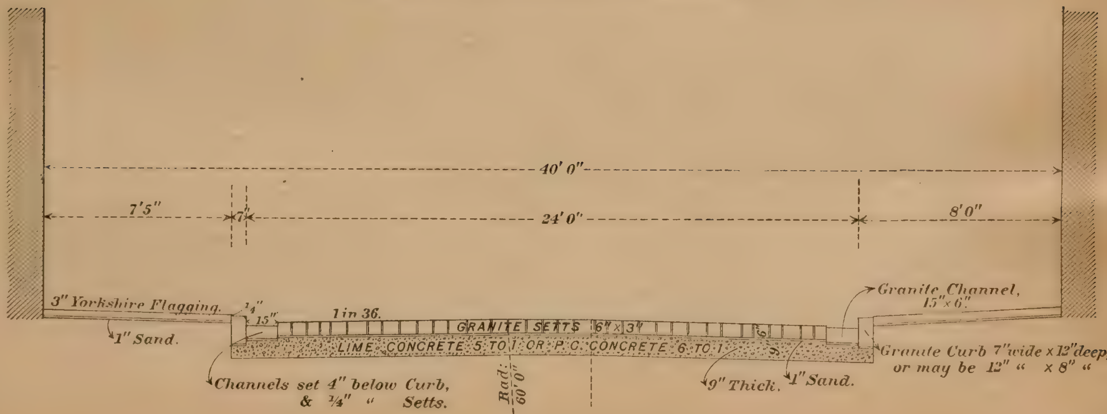
A cubic foot of asphalt weighs about 143½ pounds. A ton of asphalt laid 3 inches thick (before ramming) will cover nearly 7 square yards.

A cubic foot of gritstone weighs 155 to 170 pounds. A ton of gritstone sets, 10 inches deep and about 6 inches wide will cover 2 square yards; 8 inches deep will cover about 2¾ square yards.

BENJAMIN FOLSOM,
Consul.

UNITED STATES CONSULATE,
Sheffield, August 10, 1891.

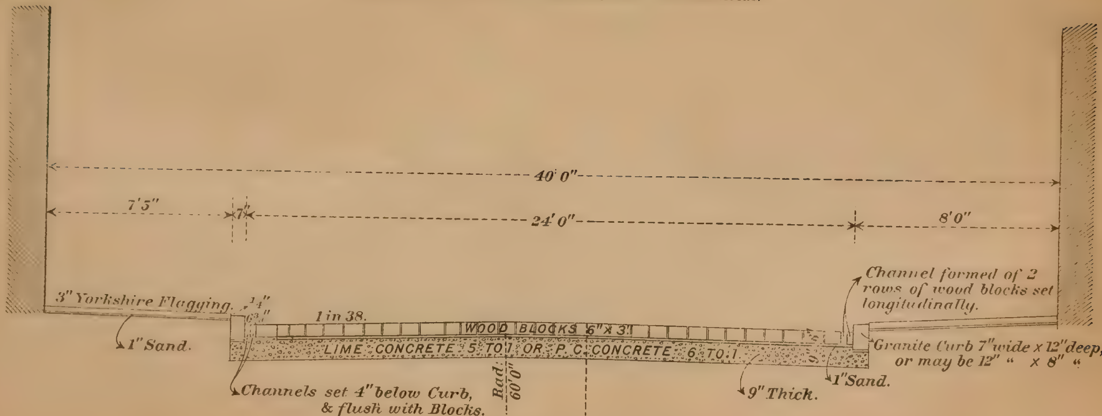
Appendix B.—Cross section of a road paved with granite setts.



Scale 6 Feet to an Inch.

[Consular Report on Streets and Highways.]

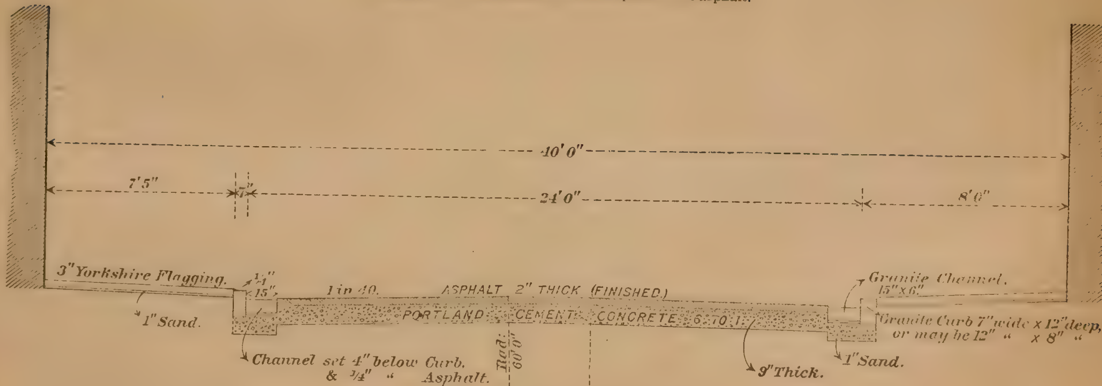
Appendix C.– Cross section of a road paved with wood blocks.



Scale 6 Feet to an Inch.

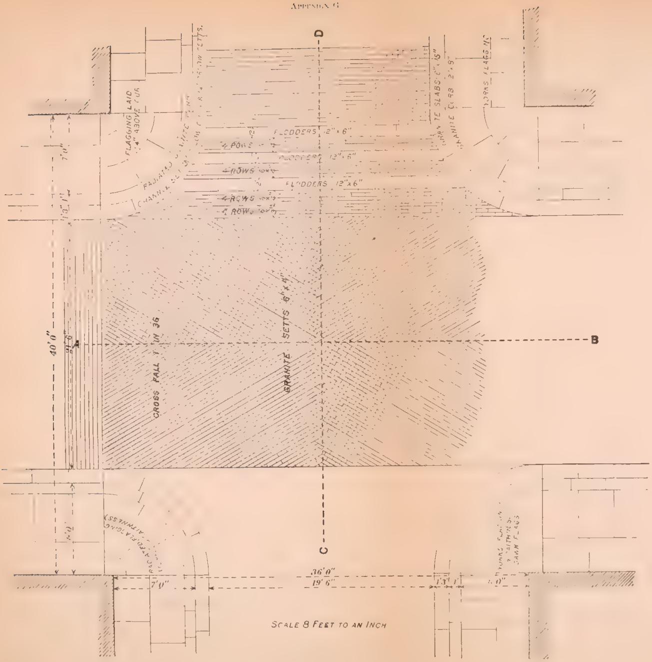
[Consular Report on Streets and Highways.]

Appendix D.—Cross section of a road paved with asphalt.



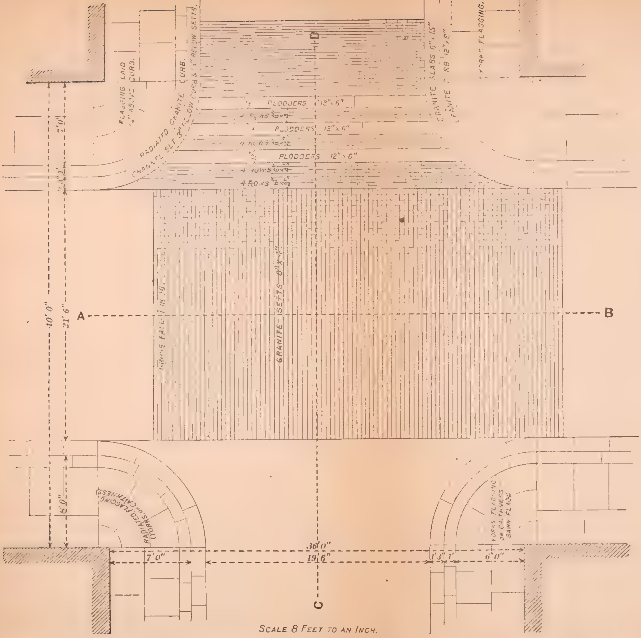
Scale 6 Feet to an Inch.

[Consular Report on Streets and Highways.]



See note in Appendix F as to levels.

[Consular Report on Streets and Highways.]



AB and CD should be perfect gradients, converging at their point of intersection the carriageway to have a camber of 1 in [illegible] at A and B, which is to be reduced by raising the line of channels so that when the line CD is reached there will be no camber; this will give a suitable "round" to the crossings at the ends of the 36 foot road, and the water from the carriageway will be thrown toward the four corners.

[Consular Report on Streets and Highways.]

INDEX.

1. HIGHWAYS.

CONSTRUCTION, MAINTENANCE, MATERIAL, COST, ETC.

2. STREETS.

CONSTRUCTION, MAINTENANCE, MATERIAL, COSTS, ETC.

3. PAVEMENTS.

4. ILLUSTRATIONS.

PROFILES OF SECTIONS, SHOWING MODES OF CONSTRUCTION, MATERIAL, ETC.

5. CONTRIBUTORS.

6. MISCELLANEOUS REFERENCES.